SALMON AND STEELHEAD HABITAT LIMITING FACTORS IN THE WILLAPA BASIN

Carol J. Smith, Ph.D.
Washington State Conservation Commission
300 Desmond Drive
Lacey, WA 98503

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This report was developed by the WRIA 24 Technical Advisory Group for Habitat Limiting Factors. Participants included:

Mark Ashley, Willapa Regional Enhancement Group
Ron Craig, Willapa Regional Enhancement Group
Lonnie Crumley, WA Dept. Fish and Wildlife
Bryan Harrison, Pacific County
Craig Graber, Dept. of Ecology
Dan Guy, Dept. of Transportation
Lillian Herger, Weyerhaeuser Company
Dr. Tom Kantz, The Willapa Alliance
Bernard Klatte, Columbia Pacific RC&D
Dave Kloempken, WA Dept. Fish and Wildlife
Bob Lake, Willapa Regional Enhancement Group
Allen Lebovitz, Coastal Watersheds Consulting
Jack Listfjeld, WA Dept. Fish and Wildlife
Dr. Mike Norman, Pacific Conservation District
Jeff Rudolph, Pacific Conservation District
Mark Scott, Pacific Conservation District
Jack Shambo, Dept. Natural Resources
Steve Spencer, Shoalwater Bay Indian Tribe

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Abstract

Through the Engrossed Substitute House Bill 2496 process, the habitat conditions of salmon-producing watersheds within WRIA 24 (with the exception of Chinook River watershed) were reviewed and summarized. Major and minor habitat factors that limit salmonid production are summarized below by watershed. Detailed reports for each of these factors are discussed within the body of the report. This first round report examines salmon and steelhead trout habitat conditions. Later versions will address the habitat issues for other salmonids.

Cedar River

The Cedar River does not currently support salmon production. However, historically the Cedar River supported coho and chum salmon. Tidegates are a major habitat problem for this river. Documentation of other habitat issues was scant for this watershed.

North River Watershed

Major habitat factors that limit salmon production in the North River Watershed include a current low level of large woody debris (LWD) throughout the basin, coupled with poor riparian conditions along the mainstem North, upper Little North, and Vesta Creek. Other major factors are excess sediment inputs from the dense network of roads, and loss of estuary habitat primarily due to dikes and tidegates. Less extensive problems include culverts throughout the freshwater coho salmon and steelhead trout areas, and channel incision, which has disconnected the river from its floodplain and associated salmon rearing areas. Peak water flows resulting from the young age of the surrounding forests are believed to contribute to channel incision. Channel incision is worsened by the lack of LWD.

Some areas (Vesta Creek, Little North River, and Redfield Creek.) have naturally low levels of gravel recruitment limiting available spawning habitat, and existing spawning habitat in this region should be protected. However, the current lack of LWD worsens the naturally low levels of spawning gravels. Pool habitat is below adequate levels, and is also a result of low LWD levels and channel incision. High summer water temperatures is another salmon habitat problem in this watershed, and poor shading from the altered riparian zones is one major cause of this problem.

Smith Creek

Spawning gravels and LWD are lacking in this basin. Previously, spawning gravel pads increased the level of spawners in these reaches, but these have been washed out or inundated by fines. Sedimentation is naturally high throughout the sub-basin, but is worsened by road-produced sediments and landslides.

Willapa Watershed

The lack of LWD is a major habitat problem for salmon throughout the Willapa Watershed. The Willapa watershed also has the highest density of roads, the greatest number of roads that cross streams, and the greatest quantity of roads in the riparian areas within the WRIA. Mass wasting sites are numerous, and combined with the road density, worsen sediment loads within the basin. The sedimentation is believed to contribute to filling (reducing) pool habitat and increasing fines, scour, and channel incision. High levels of fine sediment are a problem in the mainstem and north tributaries. These areas also have naturally low recruitment of spawning gravels, a condition that is worsened by the lack of LWD to store gravel. Scour is a significant concern in the upper mainstem, Stringer Creek, Ellis Creek, Trap Creek, and Forks Creek. Poor riparian conditions are major problems throughout the mainstem as well as in some tributaries (see Riparian Chapter for details). Other major limiting factors include high water temperatures and low dissolved oxygen in the summer months, as well as tidegates, which are barriers to estuary habitat.

Less extensive habitat problems include culverts throughout the freshwater habitat and dikes in the lower mainstem. Channel incision throughout the mainstem has further segregated the channel from historical rearing areas, and incision to bedrock has contributed (along with the lack of LWD) to few available pools for salmon. The incision is worsened by the lack of LWD and the increased sediment load from mass wasting and roads. Water turbidity is a problem in upper Fern Creek, and low flows are a problem in the upper mainstem Willapa. Stringer Creek is impacted by water withdrawals, and the dam prevents the downstream recruitment of spawning gravels. About 19% of the estuary habitat has been lost due to dikes for urban development and roads that act as dikes.

Palix Watershed

The primary salmonid habitat problems within the Palix Watershed include a significant lack of stable LWD, high road densities and road sediment inputs, extensive channel incision, and a high level of estuarine habitat loss. Gravel recruitment is fair within most channel segments of the Palix River, but incised channels require very large pieces of LWD, preferably with attached rootwads, to maintain the gravel within the needed areas. An increase in LWD would not only allow gravel storage, but would also serve to reverse the effects of channel incision by increasing instream bed elevations through gravel and sediment storage. The loss of estuarine wetlands habitat is extensive (at least 31% of historic estuarine wetlands area has been lost) primarily as a result of diking.

Minor habitat problems include a small number of freshwater culverts where fish passage is impeded, and high water velocity in the winter, which could be improved with an increase of stable, very large, woody debris.

Nemah Watershed

In the North Nemah River, major problems include high inputs of fine sediment primarily from forest roads, poor riparian conditions, a lack of LWD, floodplain loss (mostly due to riparian roads), and road-related mass wasting. The Middle Nemah River also has poor riparian conditions and a lack of LWD. The sediment inputs are not currently major problems, but if the Middle Nemah A-Line road is used for logging again, it will likely become a significant sediment problem. This road has also resulted in a significant loss of floodplain area. Diking has resulted in considerable losses of estuarine wetlands habitat in the Middle Nemah. The South Nemah River is significantly impacted by diking of estuarine wetlands and a loss of riparian shade/canopy in the lower reaches. Freshwater barriers such as culverts are a problem, although not a major limiting factor throughout the Nemah system.

Naselle Watershed

Major limiting factors throughout the Naselle Watershed include a lack of LWD coupled with poor riparian conditions (44% of the riparian consists of hardwoods, open, or young conifer). An exception to this is the mature forest in the East Fork Naselle, a critical habitat area that contributes to important salmon habitat functions. Other major habitat problems include a large number of culverts, tidegates, and riparian roads. Another extensive problem is sedimentation stemming primarily from a large number of landslides and secondarily from roads, particularly in Salmon Creek. Another major habitat problem for salmon is high water temperatures in the summer months.

Lessor problems include estuary loss due to diking, as well as concerns about the possible change in flows due to the watershed condition, with higher high flows and lower low flows as the hydrologic maturity of the surrounding forest is reduced.

Bear River Watershed

Major salmonid habitat problems in the Bear River Watershed include a lack of LWD, excessive sedimentation from landslides and roads, and a large loss of estuarine habitat. Less significant habitat problems include an immature riparian forest, which consists of young conifer and will take time to mature, as well as a concern that the reduction in hydrologic maturity is resulting in possible higher high flows and lower low flows. Culverts are few in number, but those that block salmon access should be considered a minor restoration activity.

A) INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;

- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon."

- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmonids in the state. At this time, the report identifies habitat limiting factors pertaining to salmon, steelhead trout and include bull trout when they share the same waters with salmon and steelhead. Later, we will add bull trout-only waters, as well as specific factors that relate to cutthroat.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Relative Role Of Habitat In Healthy Populations Of Natural Spawning Salmon

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Steelhead have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

Bull trout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bull trout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

Habitat Impacts

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and wood. These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors. Provided first though, is a general description of the current and historic habitat including salmon and steelhead trout populations.

B) SALMON HABITAT IN THE WILLAPA BASIN

This report identifies habitat problems within WRIA 24 (the Chinook River is addressed in the lower Columbia River report), an area that includes the Willapa Basin (Fig. B.1). Within the Willapa Basin, there are six watersheds that currently produce salmon: the North, Willapa, Palix, Nemah, Naselle, and Bear Watersheds (Fig. B.2). The largest river systems in the region are the North, Willapa, and Naselle systems. The Cedar River Watershed historically supported low numbers of coho salmon and will also be addressed to a limited degree in this report. In total, there are roughly 745 streams encompassing over 1470 linear stream miles in the Willapa region (Phinney and Bucknell 1975).

Annual rainfall in the basin has averaged about 85 inches with a range of 44-145 inches and an average of three inches of rain per month during the summer (The Willapa Alliance 1998). No streams within the Willapa basin originate from glaciers; all depend on surface and ground water inputs. Therefore, precipitation plays an important role in the quantity and quality of salmon habitat. However, Willapa Bay salinity appears to be linked not only to the Willapa Basin drainages, but also to flow from the Columbia and Chehalis River basins (The Willapa Alliance 1998). Many salinity profiles for Pacific coast estuaries shows a peak in the summer and a low in the winter, but Willapa Bay salinity drops in the late spring when snowmelt in the Columbia and Chehalis Basins is emptying into the Pacific Ocean. Because the greatest source of freshwater for Willapa Bay is the Columbia River, the Willapa Bay ecosystem depends upon the maintenance of high water quality in the Columbia River.

In this chapter, salmonid distribution is discussed along with a general habitat description. Please refer to Figure B.2 for a map that shows salmonid distribution throughout the entire WRIA 24. Because the map was reduced in size to fit the report, it might be difficult to see the chum salmon spawning distribution. Wall maps are available electronically or can be viewed at the Pacific Conservation District or The Willapa Alliance. This first-round report addresses salmon and steelhead trout. Later, cutthroat trout will be added.

Cedar River Watershed

There are a number of small independent streams along the north shore of Willapa Bay, west of the North River. The Cedar River is the largest stream in this area, and historically produced small runs of coho and chum salmon (Phinney and Bucknell 1975; Lonnie Crumley, WDFW, personal communication). It is a low gradient stream, draining the low hill area; most of the watershed is less than 400 feet in elevation (Phinney and Bucknell 1975). Its source is the south slope of Seastrand Ridge. The North Fork Cedar River provides most of the drainage.

North River Watershed

The North River and Smith Creek Watersheds drain into the northern portion of Willapa Bay, and are low gradient systems throughout their lower reaches. The North River drains nearly 229,000 acres (The Willapa Alliance 1998). Tidal influence occurs up to river mile (RM) 7.4 of the North River (Phinney and Bucknell 1975). The lower North River mainstem provides spawning and rearing habitat for winter steelhead trout, and chum, coho, and fall chinook salmon. Lower Salmon Creek is an important salmon-producing tributary with its headwaters in the hills southeast of the North River. It produces chum, fall chinook, coho salmon and winter steelhead trout. Fall chinook and chum salmon primarily use the lower 4 miles of Lower Salmon Creek, while coho salmon and steelhead trout can be found throughout the drainage (Herger 1997). Limited spawning and rearing habitat exists in Bitter Creek and the North Branch North River for fall chinook, coho, chum salmon, and winter steelhead trout (Herger 1997).

Upstream of the Highway 101 crossing, the North River is mostly a confined channel until its confluence with Vesta Creek, and spawning steelhead trout, fall chinook, coho, and chum salmon have been documented here. Chum salmon spawners have also been noted in various small tributaries that join the North River (Fig. B.2). In this area, two additional major tributaries, the Little North River and Salmon Creek, join the North River. Each supports winter steelhead trout and coho salmon spawning and rearing, as well as some fall chinook salmon spawning in the mainstem Little North River (to RM 10) and the lower 1.5 miles of Salmon Creek (Herger 1995). In the Little North River drainage, coho salmon and winter steelhead trout are also found in Mosquito Creek, Brick Creek, Beck Creek, and Black Creek (Herger 1995). Vesta Creek joins the North River at river mile 42.6 and is important for winter steelhead trout and coho salmon production, although chinook habitat exists in the lower 2 miles. It is mostly surrounded by timberland and has a very low gradient. The West and East Fork Vesta Creeks join to form Vesta Creek and both forks contribute to coho and winter steelhead production (Herger 1995).

Further upstream, the mainstem North River is utilized by fall chinook, chum, and coho salmon, and winter steelhead trout (Herger 1995). The Fall River joins the upper North River, and drains an area of about 41 square miles. Winter steelhead, coho, chum, and two different stocks of fall chinook have been documented in the Fall River drainage. One of the chinook stocks is a native early fall chinook, which use the lower 7 miles of mainstem Fall River (Herger 1995). Coho and winter steelhead use the majority of the mainstem Fall river as well as tributaries such as Moss and Boss Creeks (Fig. B.2) (Herger 1995). Chum salmon have been seen in the lower mainstem Fall River.

Near the headwaters of the North River are two other important drainages. Redfield Creek is important for coho salmon and winter steelhead production, while Raimie Creek produces coho and chinook salmon as well as winter steelhead trout.

Near the mouth of the North River is its largest tributary, Smith Creek, which drains 67.2 square miles (Phinney and Bucknell 1975). It is 27.9 miles long with over 84 lineal miles of tributaries. Smith Creek begins in the low hills northeast of Raymond, and is a low gradient stream. The lower 7 miles of mainstem provides spawning habitat for chum and fall chinook, while coho and winter steelhead habitat extends to RM 25 (Fig. B.2) (Lillian Herger, Weyerhaeuser, personal communication). Smith Creek tributaries such as Elkhorn, Clearwater, and Butte Creeks also produce coho salmon and winter steelhead trout.

Figure B.1. Location of WRIA 24.

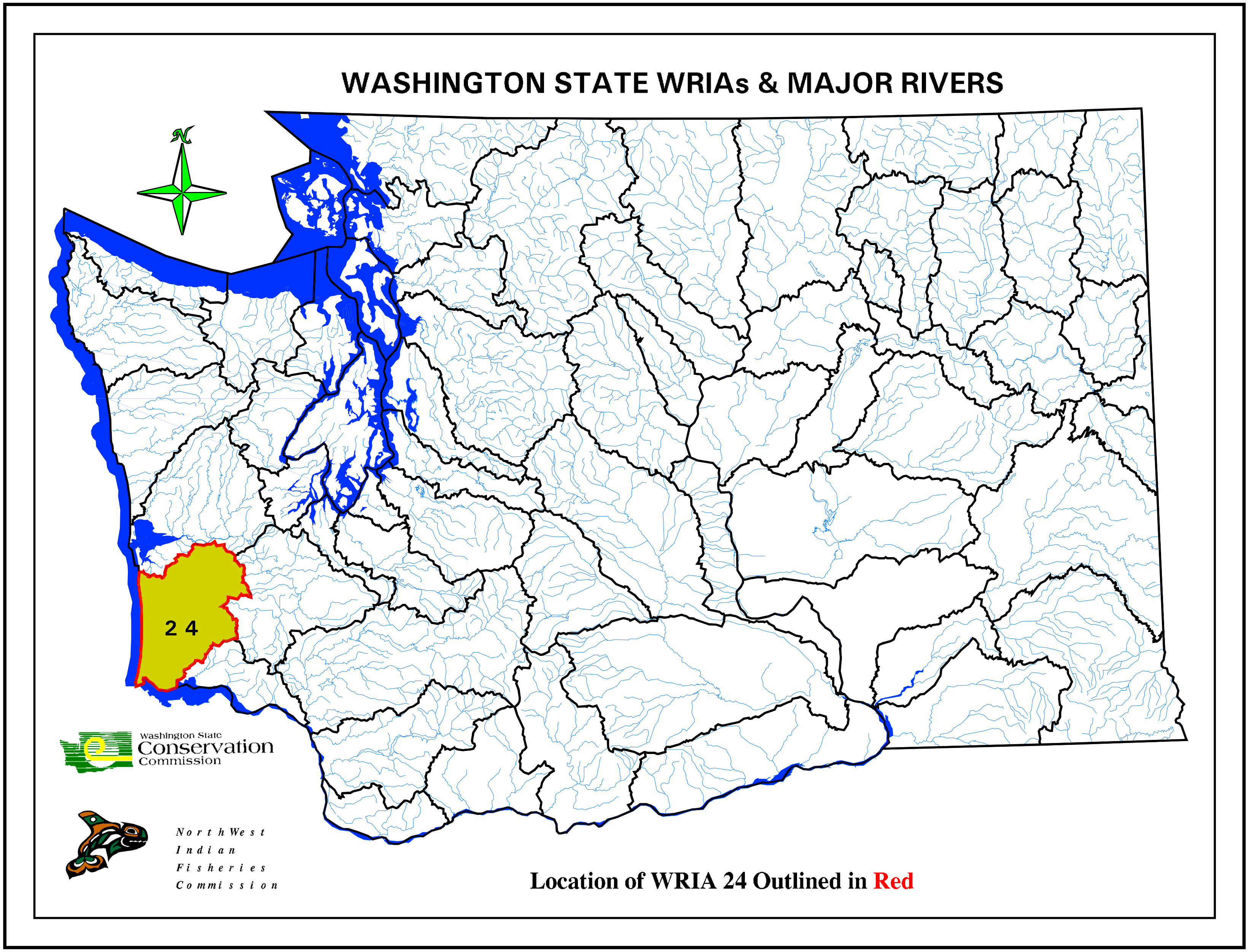


Figure B.2. WRIA 24 watersheds, salmon and steelhead distribution, and human caused barriers to salmonids (barriers are discussed in Chapter E, Loss of Access). Chum salmon distribution can be better viewed on a wall map

Willapa Watershed

The Willapa Watershed includes the Willapa River and its tributaries, which account for about 167,740 acres (The Willapa Fisheries Recovery Team 1996). It supports fall chinook, coho, fall chum salmon and winter steelhead trout. Major tributaries known to support salmon include the South Fork Willapa River, Trap Creek, Mill Creek, Wilson Creek, Fork Creek, and Ellis Creek. Smaller tributaries that produce salmon or steelhead are discussed below.

The lower Willapa River flows through the cities of Raymond and South Bend. This area of the river is tidally influenced. Marsh grass habitat exists in the side sloughs, and is important rearing and transitional habitat for chinook and chum salmon. Very little spawning habitat is present in the mainstem until about RM 7 (Phinney and Bucknell 1975), although tributaries to Skidmore Slough produce coho and chum salmon (Tom Gibbons, DNR, personal communication).

The South Fork Willapa River joins the Willapa River at about RM 7.1. It is important for spawning, rearing and as a migration corridor for fall chinook, coho, winter steelhead, and fall chum. Chum salmon use the lower 5-6 miles of the South Fork Willapa River, while chinook salmon use the lower 12 miles. Coho salmon and steelhead trout spawn throughout the South Fork Willapa River as well as in Rue Creek, a major tributary to the South Fork, which enters the South Fork Willapa at RM 9.7.

Wilson Creek enters the Willapa River at RM 12.1. This watershed contains over 11 miles of mainstem, and is a low velocity, low gradient stream (Phinney and Bucknell 1975). Winter steelhead trout, and coho and chum salmon spawn in Wilson Creek, and coho salmon have been documented in Whitcomb Creek. Steelhead trout have also been noted in Ward Creek and Fairchild Creek.

From the confluence with Mill Creek (RM 17.9) to its headwaters, the gradient of the Willapa River changes from moderate to high. Important salmon-producing tributaries in this region include Mill Creek, Stringer Creek, Trap Creek, and Forks Creek. Mill Creek supports winter steelhead, coho salmon, and low numbers of chum and fall chinook salmon. Trap Creek and Forks Creek drain into the Willapa River at RMs 29.9 and 30.5, respectively. Chinook and chum salmon and winter steelhead trout have been documented in the lower reaches, while coho salmon have been noted throughout Trap Creek (Fig. B.2) (Phinney and Bucknell 1975). Forks Creek provides habitat for chinook and coho salmon and steelhead trout. Steelhead and coho are also found in Ellis Creek, and coho are found in many small tributaries, such as Silver, Green, and Noe Creek.

A Washington Department of Fish and Wildlife salmon hatchery is located on Forks Creek, rearing and releasing fall chinook and coho salmon. The fall chinook are believed to be a mixture of native and non-native stocks (Green River, Spring Creek, Elochomin, Klickitat stocks) (Ashbrook and Fuss 1996). Two different stocks of coho are released from the facility: fall coho that were originated from native stock, although introductions have occurred throughout the years, and late coho from the Satsop River (Ashbrook and Fuss 1996).

The upper Willapa mainstem serves as spawning habitat for chinook, chum, coho, and steelhead. Chum, chinook, and coho salmon have also been found in Half Moon Creek, while coho salmon have been noted in Fern, Custer, Penny, and Falls Creeks.

Palix Watershed

Short drainage systems and relatively large estuaries characterize the Palix region. The Niawiakum River enters Willapa Bay north of the Palix River and has suitable habitat for coho and chum salmon and steelhead trout (Phinney and Bucknell 1975; Martin 1997). The Palix River consists of a short mainstem (about 9.4 miles), formed by three forks joining in tidewater about 1.5 miles from the mouth. Of these three forks, the Canon River (middle fork) has the most salmon-producing habitat.

The North Fork Palix generally has a sand-dominated bottom with little spawning gravels (Martin 1997; WDFW and WWTIT 1994), except for about one mile below a series of falls that impede upstream migration of salmon. Coho salmon, chum salmon, and winter steelhead spawn in that one mile reach below the falls (Tom Gibbons, DNR, personal communication), as well as in the limited spawning gravels downstream. Chinook salmon have been documented in the lower reach.

The South Fork Palix has limited spawning gravel, and serves primarily as rearing habitat for juvenile salmonids. Steelhead have been documented in the South Fork Palix. The lower two miles of the Canon River has a low gradient and plentiful spawning gravel, ideal for chum and fall chinook salmon (Phinney and Bucknell 1975; WDFW Spawner Survey Database). Spawning chinook have been documented up to RM 3.1 in the Canon River. The upper section of the Canon River has large numbers of cascades, and supports coho salmon and winter steelhead trout (Martin 1997).

Nemah Watershed

The Nemah River watershed contains 119 linear miles of mainstem and tributaries. It consists of three low gradient forks that flow into the central portion of Willapa Bay. The North Fork Nemah River and its major tributary, Williams Creek, provides the most important salmon habitat in the watershed. The North Fork is about 12.4 miles long with a salmon hatchery at RM 4. The North Fork and Williams Creek also support natural production of fall chinook, coho, chum, and winter steelhead. Chum salmon use the lower sections, while chinook, coho and winter steelhead spawn throughout the mainstem. Coho and steelhead also use accessible tributaries.

The Middle Fork Nemah is about 10.2 miles long. The lower reaches are tidally influenced, while the middle reaches have steep gradients. The upper reaches flow through a broad valley. The lower reaches support chinook, coho, and chum salmon as well as winter steelhead trout, while chinook, coho, and steelhead have been documented further upstream. The South Fork is the smallest of the three forks, and supports limited chum, chinook, coho and winter steelhead.

Coho salmon have been documented in Seal Slough, which is south of the South Fork Nemah River.

Naselle Watershed

The lower Naselle River is heavily influenced by the tides, with large variations in size according to the tidal stage. Several tidal sloughs and marshes comprise the surrounding habitat. Ellsworth Creek drains into the lower Naselle, and this creek supports chum, chinook, and coho salmon as well as winter steelhead throughout the mainstem and larger tributaries. The lowest mile of this creek is also tidally influenced with a silt/sand bottom. Upstream, the gradient is moderate and spawning gravel is abundant.

Smith Creek joins the Naselle at RM 5.6 and supports chum spawning and rearing. Coho and chum salmon have been documented in Holm and Petes Creeks. Further upstream at RM 10.5, Dell Creek empties into the Naselle, and produces chum, coho, and winter steelhead (WDFW Spawning Ground Survey Database). Upstream of Dell Creek, the Naselle Watershed becomes a conglomerate of tributary systems. At the town of Naselle (RM 12), the South Fork Naselle empties into the Naselle River, and represents an additional 109.7 linear miles of stream drainage. Its left bank tributaries drain the Willapa Hills and have moderate gradients, while the right bank streams drain lowland farms. Coho, fall chum salmon, and winter steelhead spawn and rear throughout the mainstem. Major tributaries such as Davis Creek, Cement Creek, Burnham Creek, and Bean Creek also provide spawning and rearing habitat for coho and winter steelhead. Chum salmon have been found in Davis, Cement, and lower Bean Creeks.

Upstream at RM 14.1 is the confluence of Salmon Creek with the Naselle River. This tributary is just over 17 miles in length and has a low to moderate gradient. Fall chinook, chum, coho salmon and winter steelhead trout spawn throughout the mainstem. Winter steelhead, chinook, and coho also spawn in Russia Creek, a tributary to Salmon Creek at RM 8.4.

Important salmon spawning, rearing, and transportation habitat for fall chinook, and coho salmon, and winter steelhead trout is found throughout the remaining upper Naselle (Fig. B.2). This area is sometimes referred to as the East Fork, and much of the mainstem is confined within a bedrock canyon. The North Fork Naselle enters the mainstem at about RM 26 and is a moderately steep stream that flows through bedrock canyons. Fall chinook, coho salmon, and winter steelhead spawn in the mainstem North Fork as well as nearby Brock Creek, while coho and steelhead also use accessible tributaries such as Savage Creek (Phinney and Bucknell 1975; WDFW and WWTIT 1994). At RM 26.5, Alder Creek joins the Naselle and provides spawning and rearing habitat for fall chinook and coho salmon and winter steelhead trout.

Bear Watershed

The Bear River drainage is relatively small, about 12.6 miles of mainstem with an additional 30.7 lineal miles of tributaries. The drainage area comprises about 30 square miles, and is the southernmost watershed emptying into Willapa Bay. The lower 3.5 miles is tidally influenced, and surrounded by marsh and deciduous brush. This area supports salmonid rearing and chum spawning. Further upstream, the gradient increases to become moderate and provides spawning and rearing habitat for chum, fall chinook, coho and winter steelhead (Phinney and Bucknell 1975; WDFW and WWTIT 1994). In the upper reaches, the uplands are mountainous with steep tributaries, providing spawning and rearing habitat for coho and winter steelhead.

Data Needs for Salmonid Distribution

- More complete salmon and trout distribution data are needed.
- Potential distribution maps should be developed.

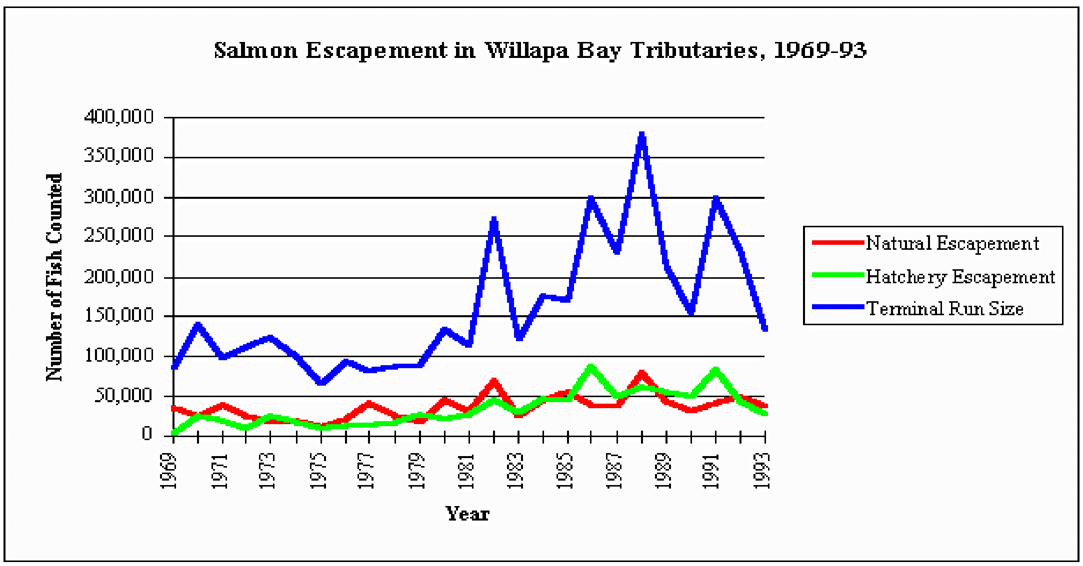
C) CONDITION OF NATURAL SPAWNING SALMON POPULATIONS IN WRIA 24

Historic Salmonid Population Condition

With the exception of three years of high catch levels, adult chinook commercial catches within Willapa Bay have been stable in the last century (Suzumoto 1992). Adult coho catches have increased from historical levels, and commercial chum salmon catches have decreased (Suzumoto 1992).

Since 1969, natural spawning levels of salmon have remained stable, while terminal run sizes (the number of adults returning to Willapa Bay) have increased (Fig. C.1) (The Willapa Alliance 1998). The increase in terminal run sizes is likely due to hatchery production, including net pen and off-station releases of hatchery-origin fish into natural habitat.

Figure C.1. Salmon Run Sizes and Spawning Levels (The Willapa Alliance 1998).



Current Salmon Population Condition

The 1992 Washington State Salmon and Steelhead Inventory, or SASSI, (WDFW and WWTIT 1994) listed only one stock in WRIA 24 as depressed, Fall River early fall chinook salmon. This stock was also defined as a native stock in the SASSI report. Coho salmon and another fall chinook stock salmon were defined as mixed-origin stocks, with one stock for each of those species spanning the entire WRIA. The status of coho was listed as unknown in SASSI, but the National Marine Fisheries Service includes this population in the Southwest Washington Coho ESU, and has defined that ESU as a Candidate Species (status wasn't resolved and will be revisited) (West Coast Coho Salmon Biological Review Team 1996). Fall chinook salmon were defined as healthy in the SASSI review. Significant hatchery returns occur for both species and if these are included in the spawning population estimates used in SASSI, the status designations could be optimistic.

Six different stocks of fall chum salmon (North River, Willapa, Palix, Nemah, Naselle, and Bear) were defined in SASSI for WRIA 24, and all were listed as healthy and native, except Naselle chum was listed as healthy but of mixed origin (WDFW and WWTIT 1994). Six different stocks of winter steelhead were described in the SASSI report for WRIA 24 (North River/Smith Creek, Willapa, Palix, Nemah, Naselle, and Bear). All were listed as native origin. Stocks in the Willapa and Naselle watersheds were designated as healthy, while those in the North, Palix, Bear, and Nemah watersheds were defined as unknown status.

Both chinook salmon and steelhead in WRIA 24 have been reviewed by the NMFS, and neither species is under any type of ESA listing proposal at this time.

Identification Of Historic Patterns Of Habitat Alterations

Hartman and Scrivener (1990) have described the common features of temperate rainforest watersheds of western Vancouver Island. These watersheds are similar to those in western Washington. The watersheds have abundant rainfall in the winter, which could result in hydrologic stress, especially in a disturbed condition. The natural, pre-disturbed conditions have mild winter and summer stream temperatures. Historically, the streams were surrounded by coniferous forests in the late seral stage. This resulted in abundant large woody debris and clean well-sorted gravels. Deep pools were numerous due to the abundant LWD, which also moderated gradient by forming step-pool profiles. James G. Swan (1992) described the Willapa area as it appeared in 1851-1854. He noted the dense growth of large forest trees consisting primarily of spruce, cedar, and fir, with a few maple ash and black alder trees. He also commented that walking through the streams was very difficult due to the presence of massive amounts of wood.

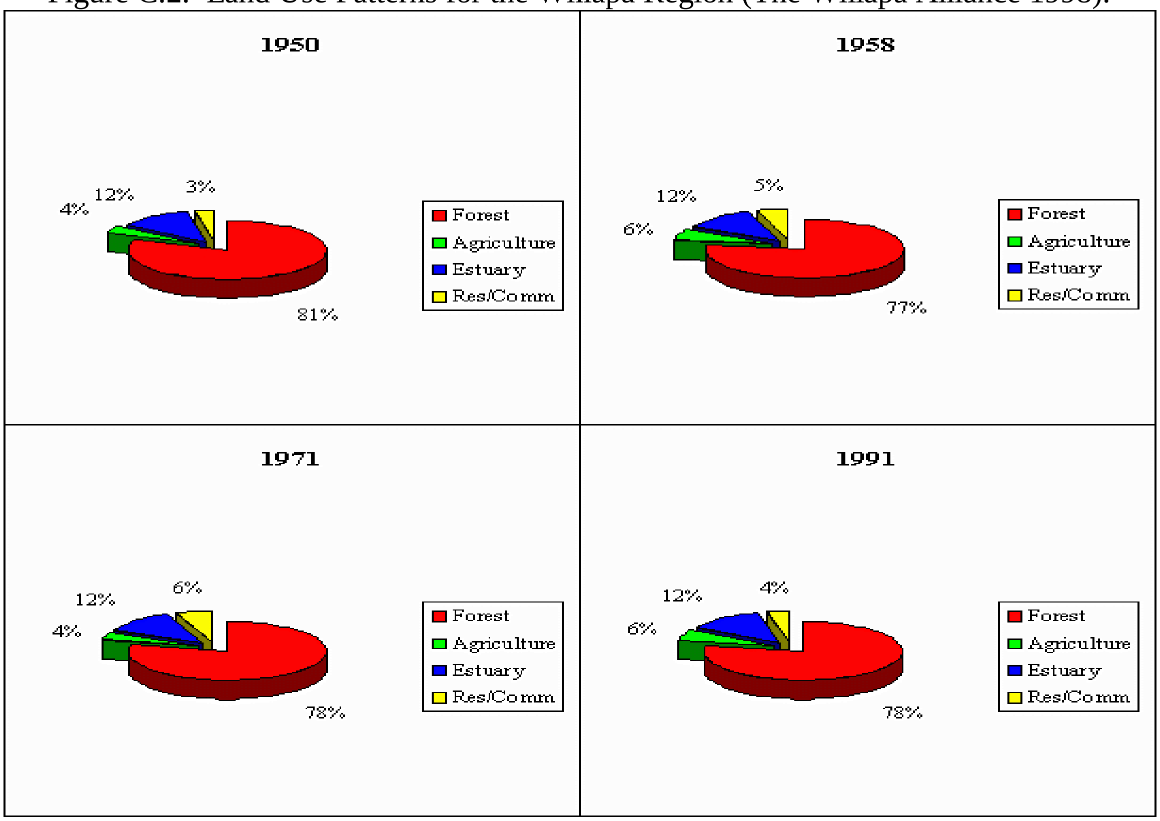
Historically, the region faced disturbances from natural fires about every 200 years. The last great fire was in the early 1400s. Since then, the climate has changed to become wetter and cooler (Pentec Environmental Inc. 1997). Tree trunks measuring from 4-10’ in diameter attest to the size of the trees with the onset of timber harvest.

Logging began in the mid-1800s, starting near the tidewater areas, and floating the logs to sawmills (Weyerhaeuser 1994). Early logging techniques such as railroad logging, steam donkeys, and log floats, were very destructive, altering stream morphology, removing LWD, and increasing sediment delivery (Seddell and Luchessa 1982). Numerous splash dams were constructed throughout the region, and their effects on channel morphology still remain today. By the 1930s, the channel impacts were large (Pentec Environmental Inc. 1997). In the 1940s, log truck use gained popularity, and roads were constructed throughout the basins. By the mid-1960s, most of the region had been logged at least once (Weyerhaeuser 1994). Today’s forest practices are much improved over these early destructive activities, but unfortunately, many of these early impacts are still present.

The floodplains in the lower reaches were cleared for agriculture, and some of these areas later became urbanized. Often, these areas have little to none of the type of riparian vegetation that used to exist along these streams. Stream clearing also occurred for flood control reasons and for misguided beliefs that salmon needed streams devoid of wood for spawning (Hadley 1994).

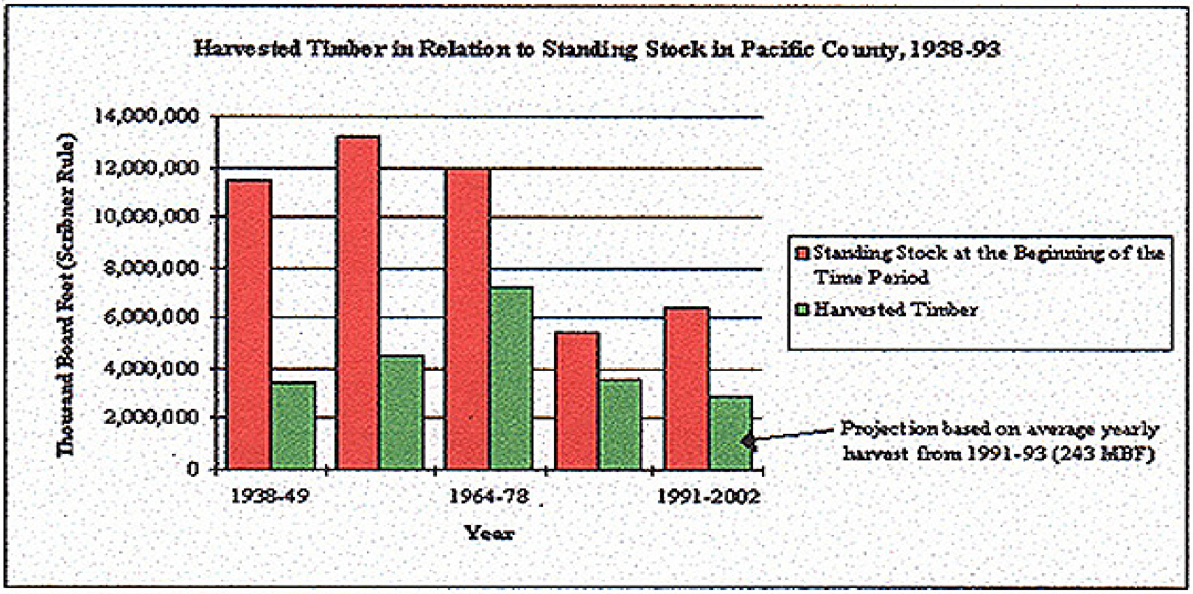
Historic and current land use patterns are summarized as follows (The Willapa Alliance 1998). Within the 600,000 acres of Willapa Basin, approximately 78% of the land is in timber production, about 12% in estuary lands, 6% in agriculture, and 4% in residential use. These percentages have remained essentially unchanged since 1950 (Fig. C.2). Less than 3% of the timberland is in permanent conservation and only a fraction of that is old growth timber (The Willapa Alliance 1998).

Figure C.2. Land Use Patterns for the Willapa Region (The Willapa Alliance 1998).



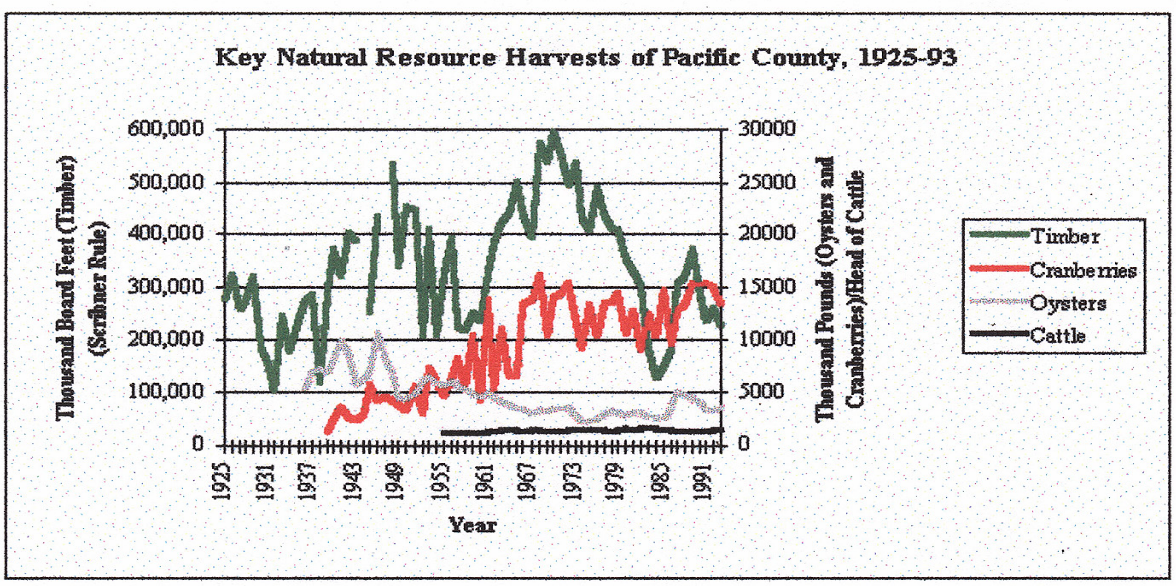
Willapa Basin timber harvest peaked during the 1970s, reducing the levels of standing stock (Fig. C.3). Because land use is dominated by timber production, timber management strategies sensitive to salmon habitat requirements will be crucial for future salmon production.

Figure C.3. Timber Harvest Patterns in the Willapa Region (The Willapa Alliance 1998).



Agriculture centers on beef cattle, dairy cattle, cranberry production, while oyster production is an important aquaculture industry in the region. In the last decade, the number of beef cattle declined significantly, while the level of cranberry harvest has increased (Fig. C.4). Cranberry production requires a significant amount of good quality surface and ground water for irrigation, temperature control, and harvesting.

Figure C.4. Natural Resource Harvest Levels in the Willapa Region (The Willapa Alliance 1998).



The 80,000 acre estuary is considered the cleanest large estuary in the continental United States (Suzumoto 1992). It is shallow, with about 50% of the high tide surface area exposed at low tide (Suzumoto 1992). There has been more than a 30% increase in salt marsh habitat in the last 120 years, even with the removal of 20% of historic marshes by diking (The Willapa Alliance 1998). However, there has been a decrease in freshwater marsh and tidelands. Native grasslands and wetlands have been altered by urbanization and agriculture, and none of the dominant grasses of the current dune grasslands is native (The Willapa Alliance 1998).

D) LOSS OF ACCESS TO SPAWNING AND REARING HABITATS

Introduction

Salmon are limited to spawning and rearing locations by natural features of the landscape. These features include channel gradient and the present of certain physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some falls may be impassable at low flows, but then become passable at higher flows. In some cases flows themselves can present a barrier such as when extreme low flows occur in some channels; at higher flows fish are not blocked.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and diversions with no passage facilities that prevent adult salmon from accessing historically used spawning grounds. However, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, in estuarine areas, dikes and levees have blocked off historically accessible estuarine areas such as tidal marshes, and poorly designed culverts in streams have impacted the ability of coho juveniles to move upstream into rearing areas. This chapter highlights known human-caused barriers to salmon and steelhead trout.

Data Sources

The Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW maintains a database on fish passage problems, and this was used as a data source (SSHEAR 1998). The Technical Advisory Group (TAG) also relied upon data contained in watershed analysis reports for the following watersheds: Little North River and Vesta Creek, Fall River, Willapa headwaters, and the Palix Basin. In addition to these published sources of data, the group included unpublished blockages identified and agreed-to within the TAG as well as recent survey data from the Pacific Conservation District.

The blockages have been assigned a low, medium, or high impact, depending on the amount of habitat blocked. Low impact was assigned to blockages of less than 0.25 miles. A medium impact was assigned to structures that blocked 0.25 to 0.99 miles. High impact was assigned to blockages of 1 mile or greater. These data were digitized, and are displayed on an enclosed 11X17 map (Fig. B.2). Wall maps are located at the Pacific Conservation District and The Willapa Alliance. Please refer to these maps for the best locational information regarding these blockages. These maps also show the documented, current salmon and steelhead distribution. When blockages are shown well outside of the range of known distribution, they are likely blockages to cutthroat trout access or to likely, but not yet documented salmon and steelhead habitat. The maps do not show cutthroat distribution or potential steelhead and salmon distribution.

Blockages In The Cedar River

Tidal gates block juvenile salmon rearing access to three nearby sloughs: Norris, Teal Duck, and Kindred (Phinney and Bucknell 1975). Even though the Cedar River does not currently support salmon production, this habitat might also be important for salmon rearing from other nearby systems, such as the North River. Estuary habitat is especially important for chinook and chum salmon.

Four freshwater human-caused blockages to anadromous salmonids in the Cedar River have been documented (data from Weyerhaeuser). Overall, these are not high impact items, especially due to the current lack of salmon in the system, but if salmon stocks are going to be recovered in this stream, these culverts should be addressed. A medium impact culvert located at 15N11W27, from the D-1800 split; completely blocks coho salmon passage. Three low impact culverts are located at:
1) 15N11W36, from the D-1800 split near the mouth.
2) 15N11W25 from the C-1000 junction.
3) 15N11W26 from the C-700 up 1/8 mile.
All of these block coho salmon access.

Blockages In The North River Watershed

Throughout the North River Basin, the number of blockages per stream mile is relatively low compared to other basins in the WRIA (about 0.025) (Pacific Conservation District). These are described below in their respective sub-basins.

<u>Lower North River</u>

In tributaries to the lower North River, there are eight impassable culverts; one identified as a medium impact, and the other seven as low impacts. The medium impact culvert is located on stream 24.0124, legal 16N9W27 on the section line (Weyerhaeuser). The low impact culverts are located as follows:

1) A perched culvert from the F Line Road (legal 16,9,27) blocks 1.5 miles of Type 3 habitat (Herger 1997).
2) A culvert is upstream of the F-Line Road culvert, in legal 16,9,21 (Weyerhaeuser).
3) A culvert is located in legal 16N,9W,28 on a tributary to the lower North River (Weyerhaeuser).
4) A culvert is located in legal 16N,9W,15 on tributary 24.0126, about 1.5 miles upstream of the mouth (Weyerhaeuser).
5) A culvert has been identified on a tributary to Joe Creek, legal 16,8,31 (Weyerhaeuser).
6) A culvert is located on Joe Creek, legal 16,8,29 (Weyerhaeuser).
7) A culvert is located on Alder Creek, legal 15,7,5 (Weyerhaeuser).

Lower Salmon Creek

Weyerhaeuser identified five culverts impassible to anadromous steelhead and coho, on tributaries to Lower Salmon Creek. One is identified as a medium impact; the remainder as low impacts. The medium impact culvert is located at legal 15N, 9W, and 10 on tributary 24.0100 about 0.25 miles from the mouth. The four low impact culverts are as follows:

1) A blockage results from the hydraulic control on Weyerhaeuser road C2700 located on tributary 24.0100, about 0.65 miles from the mouth (upstream of the medium impact culvert), legal 15,9,10.
2) A culvert is located in tributary 24.0097, about 0.8 miles from the mouth (legal 15,9,8).
3) A culvert is located from the Bishop A Line Road in a small-unnamed tributary in legal 15,9,12.
4) A culvert is located in the upper watershed on tributary 24.0096, about 0.05 miles from the mouth (legal 15,8,3).

Smith Creek

Eight impassible culverts (for coho and steelhead) were identified in tributaries to Smith Creek, and all were assigned a low impact. They are located at:
1) Butte Creek (legal 14N9W12) from the C-line near d-2120 (Dave Kloempken, WDFW, personal communication).
2) Clearwater Creek (at A-Line Road near C-Line junction) at legal 15N9W35 (Weyerhaeuser).
3) On a tributary to the West Fork Elkhorn Creek (legal 15N8W18) at Elkhorn Road near the M-300 junction (Weyerhaeuser).
4) Near the X Line and Y Line road junction, legal 15N7W17 (Weyerhaeuser).
5) On a tributary to Smith Creek near X-5100, legal 15N9W36 (Weyerhaeuser).
6) On a tributary to Smith Creek near the B-Line junction, legal 15N7W17 (Weyerhaeuser).
7) On a tributary to Elkhorn Creek from the A-Line near A-430, legal 15N8W20 (Weyerhaeuser).
8) On a tributary in the Clearwater Creek drainage, 14N9W2 (Weyerhaeuser).

Vesta Creek and Little North River Drainages

No known human-caused barriers were identified for Type 1 and 2 waters in this region. Herger (1997) expressed the possibility of partial or full barriers in Type 3 streams, but no culvert surveys have been recently conducted. This is a future research need, particularly as it pertains to spawning habitat, which is limited in this area.

Fall River

In 1995, Weyerhaeuser conducted a survey of human-caused barriers (culverts) in the Fall River drainage, and documented twelve that were impediments to fish passage (Herger 1996). Many of these culverts block cutthroat habitat, and do not pose a significant blockage to salmon distribution. All are identified as a low impact, and a few are located above cascades that are thought to be impassable to salmon. They are located as follows:

1) A culvert is located in tributary 24.0206 to Dean Creek, about 0.65 miles from the mouth, legal 15,6,33.
2) A culvert is located in a tributary to Dean Creek, about 0.1 miles from the mouth, legal 15,6,32.
3) A culvert is located in tributary 24.0217, legal 14,6,1. A cascade impassable to salmon exists downstream.
4) A culvert is located in a tributary to 24.0217, legal 14,6,1. A cascade impassable to salmon exists downstream.
5) A culvert is located in a tributary to the Fall River, legal 14,6,5. An impassable cascade exists downstream.
6) A culvert is located in stream 24.0204, legal 14,7,11.
7) A culvert is located in a small, unnamed tributary to the Fall River, legal 14,6,12.
8) A culvert is located in a small, unnamed tributary to the Fall River, legal 14,6,12.
9) A culvert is located in tributary 24.0215, about 0.15 miles from the mouth, legal 14,6,12.
10) A culvert is located in a small tributary to the Fall River at legal 14,6,10. An impassable cascade exists downstream.
11) A culvert is located in a small tributary to the Fall River at legal 14,6,15, about 0.78 miles upstream of the mouth.
12) A culvert is located in a small tributary to the Fall River at legal 14,6,15, about 0.25 miles upstream of the mouth.

Blockages In The Willapa Watershed

To-date, about 0.025 blockages per stream mile have been identified within the Willapa Watershed (Pacific Conservation District). High impact passage problems are as follows:

Upper Willapa

1) The hatchery rack on Forks Creek is located about 1 mile upstream of the mouth of Forks Creek, and although it is laddered, the passage of chinook and coho salmon is controlled at least partially by the needs of the hatchery. There appears to be disagreement about the level of natural escapement that is needed to seed the chinook and coho habitat upstream of the rack (about 7 and 18 miles of upstream chinook and coho habitat, respectively, including tributaries). It is beyond the scope of this report to work on hatchery/harvest issues, except to point out where natural production is directly

limited, and this is an example where other groups should work towards consensus regarding the seeding issue.
2) An area of low flow exists in the mainstem Willapa River near legal 13, 8, 36, where inadequate flows combined with a lack of holding pools are an impediment to adult chinook and sometimes coho upstream migration (Hadley 1994). Because the amount of habitat upstream of this area is extensive, this could be the most important blockage identified in the Willapa region.
3) Two 36" high impact culverts at RM 1.1 in Fern Creek at legal 14,7,2, block coho passage in the upper Willapa.
4) In the South Fork Willapa drainage, a culvert is located in Rue Creek, about 0.4 miles from the mouth at legal 13,8,16 (WDFW database 1998).

Medium impact passage problems are as follows:

1) In the Wilson Creek drainage, a culvert is located in legal 14,7,31 from the I-Line near I-400 (Weyerhaeuser).
2) In the upper Willapa, a culvert is located in the West Fork Ellis Creek at legal 12,7,20, associated with the F-Line near F-600.

The following are low impact passage problems:

<u>Wilson Creek Drainage</u>

1) In legal 14,7,31, a culvert is associated with I-400 near I-420 (Weyerhaeuser).
2) In legal 14,7,36, a culvert is located in a tributary to Wilson Creek (Weyerhaeuser).
3) In legal 14,7,27, a culvert is located in a tributary to Wilson Creek, 1 mile up the D-Line from the B-Line (Weyerhaeuser).
4) In a tributary to the North Fork Wilson Creek, about 0.5 miles from the mouth, a culvert is associated with A-2010 and in legal 14,7,23 (Weyerhaeuser).
5) A culvert is located in tributary 24.0299 upstream of the mouth about 0.8 miles (legal 14,9,13).
6) In legal 14,7,18, a culvert is associated with the E-Line near E-6100 (Weyerhaeuser).

<u>Upper Willapa</u>

7) A fishway maintained by Pacific County on Stringer Creek near RM 0.5 is not currently passing fish (WDFW database 1998).
8) A fishway maintained by Pacific County Trout Unlimited near RM 0.8 is not currently passing fish (WDFW database 1998).
9) A culvert is located in tributary 24.0345 (legal 12,8,2).
10) A culvert associated with the D-1500 near D-2550, is a blockage problem in a tributary to Fork Creek at legal 12,7,22 (WDFW database 1998)
11) A culvert associated with the A-Line near the D-Line junction in legal 12,7,15, is a blockage problem in a tributary to Fork Creek (Weyerhaeuser).
12) A culvert in a tributary to Fork Creek is located in legal 12,7,15 and associated with the A-Line near A-2800 (Weyerhaeuser).

13) A culvert poses a blockage problem in tributary 24.0387, about 0.1 mile from the mouth in legal 12,7,12.

<u>South Fork Willapa Watershed</u>
14) A culvert blockage problem exists in Fall Creek, about 1.5 miles from the mouth (legal 13,9,13) (Weyerhaeuser).
15) In tributary 24.0292 about 0.5 miles from the mouth, is a culvert blockage problem (legal 13,9,25) (Weyerhaeuser).

<u>Lower Willapa River</u>

These two blockages were identified by Tom Gibbons (DNR), and were not available in time to include on the map.

1) On the south side of Mill Creek Road (legal 13,8,2), the creek has been diverted from its original channel due to the railroad grade. This is in the "u" shaped channel near the mouth of Mill Creek.
2) An undersized culvert in Browns Creek, a tributary to Skidmore, is located in legal 14,9,35.

Blockages In The Palix Watershed

A few potential barriers have been noted by Tom Gibbons, DNR, personal communication. These data were not available in time to include on the map. They are located as follows:

1) Undersized culverts are located where Church Road crosses Nichol's Creek on the North Palix (legal 13,9,4).
2) In legal 13,9,29, a tributary to Canyon Creek is diverted into a ditch connecting to Canyon Creek.
3) A partially collapsed log stringer bridge near the 2050 and 2051 Road intersection impounds water in the Middle Palix (legal 13,9,33).
4) A partially collapsed log stringer bridge associated with the A Line Road, impounds water in the Palix in legal 12,9,5.

Blockages In The Nemah Watershed

The Nemah Watershed has 0.054 blockages per stream mile currently identified. Per stream mile, this is the highest level in the WRIA. Twelve culverts were identified in the NemahWatershed, one is a high impact blockage, two are medium impact access problems, and nine are low impact culverts. The high impact blockage is as follows:

1) A culvert in a tributary to Williams Creek, associated with the A-Line near A-2300 in legal 12,9,16 (Weyerhaeuser). This culvert blocks significant Type 3 and 4 habitat.

The medium impact culverts are as follows:

1) A culvert is located about 0.1 mile upstream of the mouth in tributary 24.0461, a tributary to Williams Creek, legal 12N,10W,12 (Pacific Conservation District).
2) A culvert in the North Nemah basin, about 0.1 mile upstream of the mouth in tributary 24.0488 poses access problems for Type 3 and Type 4 habitat (legal 12,9,34) (Pacific Conservation District).

The low impact culverts are as follows:

1) A culvert in a tributary to Williams Creek, legal 12,9,7, is associated with the D-Line near D-200 (Weyerhaeuser).
2) A culvert in a tributary to Williams Creek, legal 12,9,16, is associated with the A-Line near A-2200 (Weyerhaeuser).
3) A culvert in a tributary to Williams Creek, legal 12,9,17, is associated with the A-Line near A-1700 (Weyerhaeuser).
4) A culvert about 0.1 mile from the mouth in tributary 24.0540 blocks potential salmon rearing habitat (legal 12,10,28). It is not located in an area of known spawning (Weyerhaeuser)
5) In a tributary to the North Nemah River, a culvert associated with the E-700 Line blocks Type 4 habitat and a small quantity of Type 3 habitat (Weyerhaeuser).
6) About 0.1 miles from the mouth in tributary 24.0487 (a tributary to the North Nemah) a culvert blocks Type 3 and Type 4 habitat in legal 12,9,33 (Pacific Conservation District).
7) A culvert blocks a small quantity of Type 3 and Type 4 habitat. It is located about 0.5 miles upstream of the mouth in tributary 24.0514, a tributary to the Middle Nemah River (legal 11,9,9) (Pacific Conservation District).
8) In the upper Middle Nemah River, a culvert at legal 11,9,13 blocks a small quantity of potential coho and steelhead habitat (Pacific Conservation District).
9) A culvert in a tributary to the North Nemah River (legal 12,9,32) is associated with the H-Line near H-200 (Weyerhaeuser).

Blockages In The Naselle Watershed

The Naselle Watershed currently has 0.050 identified blockages per stream mile. This is significant considering that only a small amount of habitat has been surveyed for blockages. A future data need is to complete habitat surveys in the Naselle Watershed. To-date within the drainage, 21 culverts that obstruct anadromous passage were identified with three listed as high impact, one medium impact, and the remainder as low impact. The three high impact culverts are as follows:

1) In Johnson Creek, a culvert from State Rt. 4 at RM 0.5, results in passage problems for coho and chum salmon to 2.1 miles of upstream habitat (legal 10,9,4) (WDFW Fish Passage Database 1998).

2) A culvert in Cement Creek (at RM 0.1 from SR 401), a tributary to the South Fork Naselle River, blocks 2 miles of coho and chum salmon habitat (legal 10,9,21 center) (WDFW Fish Passage Database 1998).
3) In Burnham Creek, a logging road culvert at the mouth blocks a half mile of coho salmon habitat (legal 10,9,21) (WDFW Fish Passage Database 1998).

The medium impact culvert is located in tributary 24.0603, about 0.75 miles from the mouth (legal 10,9,34) (WDFW Fish Passage Database 1998).

The low impact culverts are as follows:

1) A culvert in a tributary to Alder Creek (legal 11,8,3) blocks a small quantity of potential steelhead and coho habitat (Pacific Conservation District).
2) A culvert in a tributary to Alder Creek (legal 11,8,4) blocks potential steelhead and coho habitat (Pacific Conservation District).
3) A culvert in a tributary to the North Fork Naselle is located at legal 11,8,5 (Pacific Conservation District).
4) A culvert in a tributary to the North Fork Naselle is located at legal 11,8,9 (Pacific Conservation District).
5) A culvert in tributary 24.0662 is located at legal 11,7,7 (Pacific Conservation District).
6) In a tributary (24.0642) to Brock Creek, a culvert is located about 0.1 miles from the mouth and blocks both Type 3 and Type 4 habitat (legal 11,8,18) (Pacific Conservation District).
7) In a tributary to the upper Naselle River, a culvert blocking Type 4 habitat is located at legal 11,8,19 (Pacific Conservation District).
8) In a tributary to the upper Naselle River, a culvert blocking both Type 3 and Type 4 habitat is located at legal 11,9,25 (Pacific Conservation District).
9) In tributary 24.0637, about 1.5 miles from the mouth, a culvert at legal 11,9,26 blocks both Type 3 and Type 4 habitat in the upper Naselle River (Pacific Conservation District).
10) Two culverts exist in tributary 24.0633. The lower culvert should be addressed first. It is located about 0.1 miles from the mouth at legal 10,9,2 (Pacific Conservation District).
11) The second culvert in tributary 24.0633 should be addressed after the downstream culvert (number 10 above). The second culvert is located about 1 mile from the mouth in legal 11,9,35 (Pacific Conservation District).
12) A culvert is located in a small tributary to the upper Naselle River in legal 10,8,6 (Pacific Conservation District).
13) In a tributary to Salmon Creek, a culvert is associated with SR-4 in legal 10,9,13 (WDFW Fish Passage Database).
14) In tributary 24.0587 (legal 10,9,16) a culvert is located about 0.75 miles from the mouth (WDFW Fish Passage Database).
15) In a tributary to the upper South Fork Naselle River, a culvert is associated with SR-401 (legal 9,9,4) (WDFW Fish Passage Database).
16) In a tributary to the upper South Fork Naselle River, a culvert is associated with SR-401 (legal 9,9,5) (WDFW Fish Passage Database).

17) In tributary 24.0635, about 0.1 miles from its mouth is a culvert in legal 11,8,31 (Pacific Conservation District).

Blockages In The Bear River Watershed

The Bear River has been extensively surveyed for freshwater barriers, and only four have been identified (Pacific Conservation District). Blockages per stream mile is 0.040 (Pacific Conservation District). All are listed as a low impact, and are as follows:

1) In tributary 24.0684, about 0.5 miles from its mouth, is a culvert in legal 10,10,8 blocking both Type 3 and Type 4 habitat.
2) Two culverts have been found in tributary 24.0696, and the downstream-most culvert should be addressed before the upstream culvert. The downstream culvert is about 1 mile from the tributary's mouth in legal 10,10,16.
3) The upstream culvert in tributary 24.0696 is located about 1.8 miles from the mouth in legal 10,10,16.
4) A culvert in legal 10,10,26 blocks both Type 3 and Type 4 habitat.

Data Needs For Loss Of Access in WRIA 24

- Tidegate analysis is needed throughout the Willapa Basin, including the Cedar, North, Willapa, Palix, Nemah, Naselle, and Bear Rivers.
- Culvert analysis is needed in the North River, Willapa River, and Naselle River.

E) FLOODPLAIN CONDITIONS IN WRIA 24

Functions of Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. In general, most floodplain areas are located in lowland areas of river basins and are associated with higher order streams. Floodplains are typically structurally complex, and are characterized by a great deal of lateral, aquatic connectivity by way of sloughs, backwaters, sidechannels, oxbows, and lakes. Often, floodplain channels can be highly braided (multiple parallel channels).

One of the functions of floodplains is aquatic habitat. Aquatic habitats in floodplain areas can be very important for some species and life stages such as coho salmon juveniles that often use the sloughs and backwaters of floodplains to overwinter since this provides a refuge from high flows. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape, lessening the impact of floods on incubating salmon eggs. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes. This acts as a filter of nutrients and other chemicals to maintain high water quality.

Impairment of Floodplains by Human Activities

Large portions of the floodplains of many Washington rivers, especially those in the western part of the state, have been converted to urban and agricultural land uses. Much of the urban areas of the state are located in lowland floodplains, while land used for agricultural purposes is often located in floodplains because of the flat topography and rich soils deposited by the flooding rivers.

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain. This occurs both laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. Channels can also become disconnected from their floodplains as a result of downcutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. The natural riparian and terrestrial vegetation in floodplain areas was historically coniferous forest. Conversion of these forested areas to impervious surfaces, deciduous forests, meadows, grasslands, and farmed fields has occurred as floodplains have been converted to urban and agricultural uses. This has: 1) eliminated off-channel habitats such as sloughs and side channels, 2) increased flow velocity during flood events due to the constriction of the channel, 3) reduced subsurface flows, and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed.

Elimination of off-channel habitats can result in the loss of important rearing habitats for juvenile salmonids such as sloughs and backwaters that function as overwintering habitat for coho juveniles. The loss of LWD from channels reduces the amount of rearing habitat available for chinook juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

North River Floodplain Conditions

Lower North River

About 479 acres of off-channel habitat have been lost in the North River Basin (The Willapa Alliance 1998). This accounts for about 10 % of the historical available off-channel habitat. Dikes along the lower mainstem (Herger 1997), prevent the development of shallow off-channel regions that would function as rearing habitat for chum, coho, steelhead, and chinook, as well as provide winter high flow refuge. These dikes were built at the turn of the century to allow land to be developed for farming and livestock grazing. Several floodgates were installed with one-way covers to allow water to drain out, and prevent water from entering the historic floodplain. The density of riparian roads is a lesser concern at 1 mile of riparian roads per square mile of watershed (The Willapa Alliance 1998).

The Lower North River mainstem is incised (Herger 1997), which further limits off-channel rearing habitat. It isn't known how much of this is due to past splash dams or whether some of it is a natural condition.

Little North River and Vesta Creek

Riverine wetlands are common in this sub-basin and provide some rearing habitat for salmonids, although the location of these rearing sites are in smaller tributaries and located far away from the limited spawning areas. In addition, beaver dams create backwater swamps, although these swamps may be associated with low levels of dissolved oxygen in the summer. In the North River mainstem where juvenile rearing habitat would be of greatest value, the channel is incised and disconnected from its floodplain (Herger 1995). A survey in this area documented 3 side-channels, no lateral ponds, and 1 mid-channel bar in the 14-mile reach of the mainstem North River. The small tributaries are also entrenched and may offer only limited winter rearing habitat.

Fall River

The Fall River mainstem is moderately to tightly confined, precluding the availability of off-channel and extensive side-channel habitat. This makes the low gradient tributaries very important for winter rearing. Upper Moss Creek seemed to be an important winter rearing area for coho and winter steelhead (Herger 1996), as well as containing adequate stream margin habitat for fry.

Willapa Watershed Floodplain Conditions

The Willapa Watershed has lost about 162 acres of off-channel habitat, which account for about 12% of the total historical available off-channel habitat (The Willapa Alliance 1998). The density of riparian roads is high, at 3 miles of riparian roads per square mile of watershed (The Willapa Alliance 1998). In the upper Willapa River, there are few side channels because the mainstem has incised into its floodplain (Sullivan and Massong 1994).

Floodplain Conditions In The Palix, Bone, And Niawiakum Rivers

Off-channel habitat in the Palix Watershed has been lost due to a combination of agricultural and timber impacts, with an estimated total of 58 acres lost (The Willapa Alliance 1998). This accounts for about 14% of the historical level of off-channel habitat, and is considered to be a conservative estimate of the loss. Only five off-channel areas were documented along the entire anadromous zones of the Middle Palix River, and none were noted in Canyon Creek and Niawiakum River (Martin 1996). Numerous splash dams documented in the watershed are likely causes of significant channel downcutting to bedrock, disconnecting the channels from their floodplain. In addition to this loss, riparian road density is moderate at 2 miles of riparian roads per square mile of watershed (The Willapa Alliance 1998).

Wetlands are common in the upper Bone, Bruceport Creek, Niawiakum, and South Palix Rivers, but they are located far away from spawning areas (Martin 1996), so their direct role in salmon juvenile rearing is questionable. However, they can play an indirect role in moderating water quality and flows.

Nemah Watershed Floodplain Conditions

The Nemah Watershed has lost an estimated 6 acres of off-channel habitat, accounting for only about 0.8% of the total historical level, although this is believed to be a very conservative estimate (The Willapa Alliance 1998). However, the density of riparian roads is high, about 3 miles of riparian roads per square mile of watershed, which may account for additional loses beyond the 0.8% listed above (The Willapa Alliance 1998).

Naselle Watershed Floodplain Conditions

The Naselle Watershed has lost an estimated 18 acres of off-channel habitat, accounting for about 2% of the total historical level (Willapa Alliance 1998). However, the density of riparian roads is high, about 3 miles of riparian roads per square mile of watershed, and this may account for additional loses beyond the conservative estimate of 2% loss (The Willapa Alliance 1998).

Bear River Watershed Floodplain Conditions

The Bear River Basin has lost an estimated 0.7 acres of off-channel habitat, accounting for about 3% of the total historical level, although this is believed to be a very conservative estimate (The Willapa Alliance 1998). However, the density of riparian roads is the highest in the WRIA, about 3.2 miles of riparian roads per square mile of watershed (The Willapa Alliance 1998).

Data Needs For Floodplain Conditions In WRIA 24

- All of the Willapa Basin watersheds (North, Willapa, Palix, Nemah, Naselle, and Bear Watersheds) need a comprehensive inventory of freshwater wetlands, as well as a map showing the loss of floodplain habitat.

F) STREAMBED SEDIMENT CONDITIONS IN WRIA 24

Streambed Sediment Introduction

The sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes which input, store, and transport the materials. Processes naturally vary spatially and temporally and depend upon a number of features of the landscape such as stream order, gradient, stream size, basin size, geomorphic context, and hydrological regime. In forested mountain basins, sediment enters stream channels from natural mass wasting events (e.g. landslides and debris flows), surface erosion, and soil creep. Inputs of sediment to a stream channel in these types of basins naturally occurs periodically during extreme events such as floods (increasing erosion) and mass wasting which are the result of climatic events (e.g., rainstorms, rain on snow). In lowland, or higher order streams, erosion is the major natural sediment source. Inputs of sediment in these basins tend to be steadier in geologic time.

Once sediment enters a stream channel it can be stored or transported depending upon particle size, stream gradient, hydrological conditions, availability of storage sites, and channel type or morphology. Finer sediments tend to be transported through the system as wash load or suspended load, and have relatively little effect on channel morphology. Coarser sediments (>2 mm diameter) tend to travel as bedload, and can have larger effects on channel morphology as they move downstream, depositing through the channel network.

Some parts of the channel network are more effective at storing sediment, while other parts of the network are more effective at transporting material. There are also strong temporal components to sediment storage and transport, such as seasonally occurring floods, which tend to transport more material. One channel segment may function as a storage site during one time of year and a transport reach at other times. In general, the coarsest sediments are found in upper watersheds while the finest materials are found in the lower reaches of a watershed. Storage sites include various types of channel bars, floodplain areas, and behind LWD.

Effects of Human Actions on Sediment Processes

Changes in the supply, transport, and storage of sediments can occur as the direct result of human activities. Human actions can result in increases or decreases in the supply of sediments to a stream. Increases in sediment result from the isolation of the channel from the floodplain by development of lowland areas (diking and roading); this eliminates important storage areas for sediment. In addition, actions that destablize the landscape in high slope areas such as logging or road construction increase the frequency and severity of mass wasting events. Finally, increases in the frequency and magnitude of flood flows increases erosion. These increases in coarse materials fill pools and aggrade the channel, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids. Increases in total sediment supply to a channel increases the proportion of fine sediments in the bed which can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Decreases in sediment supply occur in some streams. This occurs primarily as a result of disconnecting the channel from the floodplain. A dam can block the supply of sediment from upper watershed areas while a levee can cut off upland sources of sediment. Reduction in sediment supply can alter the streambed composition, which can reduce the amount of material suitable for spawning.

In addition to affecting sediment supply, human activities can also affect the storage and movement of sediment in a stream. An understanding of how sediment moves through a system is important for determining where sediment will have the greatest effect on salmonid habitat and for determining which areas will have the greatest likelihood of altering habitats. In general, transport of sediment changes as a result of the isolation of the channel from its floodplain. This increases in the magnitude and frequency of flood flows. Larger and more frequent flood flows moves larger and greater amounts of material more frequently. This can increase bed scour, bank erosions, and alter channel morphology, and ultimately degrade the quality of spawning and rearing habitat. Unstable channels become very dynamic and unpredictable compared to stable channels in undeveloped areas. Additional reductions in the levels of instream large woody debris (LWD) can greatly alter sediment storage and processing patterns, resulting in increased levels of fines in gravels and reduced organic material storage and nutrient cycling.

Streambed Sediment Conditions In The North River Watershed

Lower North River And Salmon Creek

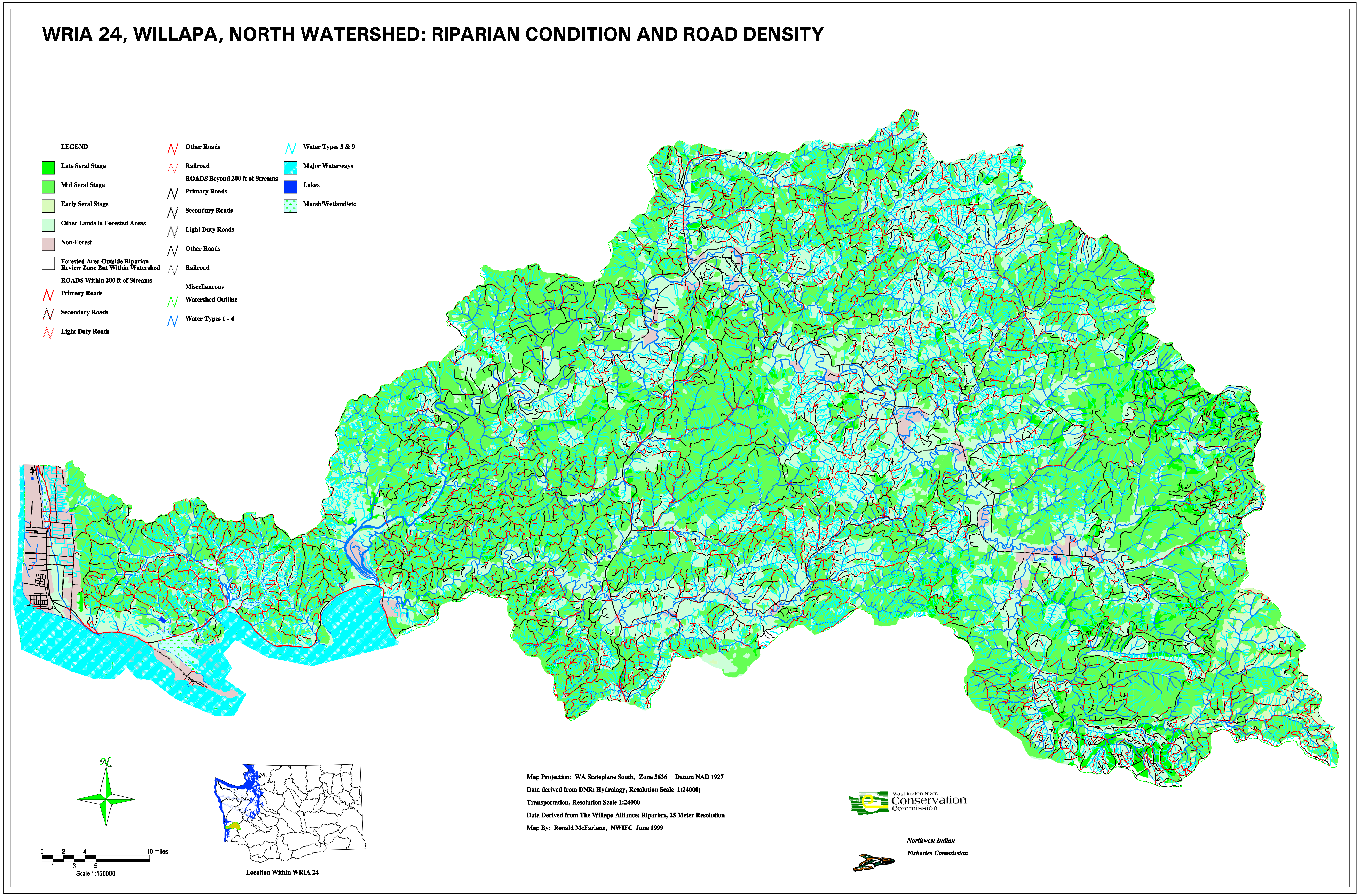
The lower North River mainstem provides several functions for anadromous salmonids. It is a major migration corridor for chinook, coho, and chum salmon, as well as for steelhead trout. It also provides spawning habitat for chinook and chum salmon and rearing for juvenile chinook, coho, and steelhead, especially in the tidal zone sloughs. Historically, there were four splash dams located in the North River. All built prior to 1920. These were complete barriers to anadromous salmon for about 10 years (Herger 1997). In addition to blocking access to about 60% of the potential salmon habitat, splash damming also resulted in: removal of LWD, channel scour, physical injury to fish and eggs during water releases, channel incision, removal of spawning gravel, and decreased stability of gravels (Wendler and Deschamps 1955). Some of these splash dam impacts are still visible today.

Good spawning gravels are limited in the lower North River. About 48% of the sampled areas in the lower North River watershed were rated as "low" in spawning habitat quality based upon the type of dominant and subdominant substrate present in the samples (Herger 1997). About 45% were rated as "medium" and only 6% rated as "high" spawning quality. Gravel quantity rated better, with 45% rated "high", 29% rated "medium", and 26% rated "low" (Herger 1997). Most of the sampled sites were in the smaller streams; the lower mainstem was not included in this rating. It was noted that coarse sediment builds up in the mainstem North River near the mouth of Salmon Creek, and that balls of fine sediment are common in the mainstem North River.

The total road density in the basin is high at 4.1 miles/square mile of watershed (Fig. F.1) (The Willapa Alliance 1998), and the mid-slope roads pose the greatest risk of fine sediment release, except in the North Branch and Lower Salmon (Herger 1997). The NMFS rated road densities of greater than 3 miles/square mile of watershed as “not properly functioning”; their highest level of impact (NMFS, 1995). Road crossings and stream-adjacent roads are less numerous than mid-slope roads, but are still a concern (Herger 1997). Roads that cross streams number 7.8 per square mile of watershed, while riparian road density is 1 mile/square mile of watershed. These levels are among the lowest in WRIA 24 (The Willapa Alliance 1998).

Large woody debris has several important salmonid habitat functions including: creating pools, cover in pools, gravel sorting and retention, water velocity reduction, and channel morphology. While 45% of sampled sites were rated as having "high" levels of LWD (Herger 1997) based upon Watershed Analysis Manual (WFPB 1995), much of this was old logging debris. About 19% of the surveyed areas were rated "medium" in LWD quantity, and 35% rated "low" (Herger 1997). Most of the sampled sites were in the smaller streams. The lower mainstem was not included in the sampling, and is generally low in current levels of LWD (Lillian Herger, Weyerhaeuser, personal communication). Nearly the entire lower North River watershed has low near-term wood recruitment potential (see Fig. G.1 in the Riparian Chapter) (Herger 1997). Selective wood removal occurred in the mainstem lower North River in 1983, and several debris jams were removed from Salmon Creek throughout the 1970s (Herger 1997).

Figure F.1. Road density and riparian vegetation type in the North River Watershed (The Willapa Alliance 1998).



Streambed Sediment Conditions In Little North River And Vesta Creek

The Vesta Creek and Little North River watersheds had several splash dams in the early part of the century. They were located in the North River (two dams), Little North River (three dams), Lower Vesta Creek (1 dam), and Salmon Creek (1 dam), and resulted in channel scour with a loss of wood, gravel and vegetation (Clark 1995). They also contributed to channel straightening, which increased water velocity and subsequent scour, as well as decrease habitat complexity. Splash dams were removed by the 1950s, but their long-term impacts on channel morphology remain today. Splash dam channels are dish-shaped with very low habitat complexity and connectivity (Clark 1995).

Railroad logging was replaced with truck logging by the 1950s, which has increased road density. Also in the early stages of timber harvest, railroad development resulted in huge cuts and fills in the landscape. In the 1940s, road construction began near the railroads, increasing the cuts and adding sidecast to the railroad fills (Clark 1995).

There were few known natural large-scale fires in this watershed prior to settlement by pioneers. No fires were recorded in the General Land Office surveys from 1878-1900 (Clark 1995), and according to Agee (1993), the frequency of natural fires for this area is about one fire every 750-1100 years. However, by the 1930s, large areas of the Vesta Creek sub-basin had been slash burned at least once (Clark 1995). In the 1970s, "stream cleaning" occurred in the basin, which removed LWD under the mistaken belief that salmon needed "wood-free" streams for spawning and access.

Recently, some positive changes have occurred in harvest management including: decreased burning, better riparian protection, and smaller harvest units. This has resulted in growth of the riparian vegetation, but there are still problems, such as mass wasting, road erosion, lack of LWD, and incision of channels (Clark 1995). Some of these problems are the result of the early timber harvest practices.

The majority of streams in this region are low-gradient which are sensitive to accumulations of fines and have reduced ability to transfer gravels and wood. Gravel is only present near its source, and is naturally low throughout this region. This limits salmon production. Upper Vesta Creek has the best spawning habitat, but a lack of LWD in this area greatly reduces gravel sorting and retention (Clark 1995). Improving LWD levels and future LWD recruitment potential in this area would greatly aid salmon habitat functions. In other areas of this watershed, there are few sources of good spawning gravels.

Historically, good spawning habitat existed in the middle mainstem North River , but splash dams washed out gravels and old timber harvest practices introduced fines that covered gravel. The existing geology prevents the timely development of new spawning habitat, as it would require massive levels of large wood.

Landslide frequency has increased since 1955 and the majority of landslides have been related to road construction. A total of 335 landslides were identified in the 1995 Watershed Analysis (Clark 1995). Of those, 169 were shallow rapid slides that developed into debris flow (saturated to become a viscous flow of water, soil, rock, and organic debris), 138 were shallow rapid landslides usually associated with large storms, and 28 were deep-seated landslides. Landslides associated with roads accounted for 79% of the total, and were the result of railroad fill, railroad sidecast, and road construction sidecast (Clark 1995). The railroad fill failures usually develop into extremely damaging debris flows and restoration of these areas would improve future salmon production. The sediment in these debris flows usually enter the steep Type 4 and 5 streams and are delivered to the low gradient channels where most of the sub-basin salmon production occurs.

Of the 21% (70) of total landslides that were not associated with railroads or road construction, most were in young (0-20 years) harvest units (Clark 1995). Both road-associated and young stand-associated landslides increase in frequency with large precipitation events. However, landslides in older stands are less frequent (Clark 1995).

The sediment input from roads exceeded the levels of estimated background erosion in the North River (RM 26-46.5) and was comparable to the background estimate in the mainstem Vesta (Clark 1995). Road length has increased from 337 miles in 1955 to 547 miles in 1995 (Clark 1995). Riparian roads and roads that cross streams (Fig. F.1) deliver sediment at a high rate, and many of the riparian roads act as dikes, disconnecting the river from the floodplain. Midslope roads also deliver significant levels of sediment, while ridge roads deliver little sediment. Fine sediment from surface erosion of landslide scars and from hillslopes was small relative to background levels and to road contributions (Clark 1995).

High levels of fines reduce egg survival to emergence, and fines are a problem in the Upper Vesta due to mass wasting and road density (Clark 1995). Due to the limited amount of quality spawning gravels in upper Vesta Creek, fine sediment delivery to this area is a concern in order to maintain the best spawning habitat. Mass wasting also occurs in the upper Little North River watershed and in some of the tributaries to Salmon Creek (Clark 1995).

Wide scale deposition and/or scour were noted in the North River tributaries, Salmon Creek, Little North River, and mainstem Vesta tributaries (Peacock 1995). In general, channels have widened between 1967 and 1978, with little change from 1978-1994. The mainstem North River (RM 26-46.5) has narrowed, perhaps due to incision from splash dams. Upstream of the upper limit of splash dams is a transition from incised channels to more stable channels. However, active downcutting occurs in response to the instability of the mainstem channels (Peacock 1995).

The widespread trapping of mountain beaver in the 19th century has contributed to channel incision in the small, low-gradient streams throughout the North River Watershed. Beaver dams contribute to stream roughness, which dissipates stream energy. These dams also store and regulate sediments (10,000 Year Institute, in preparation).

<u>Streambed Sediment Conditions In The Fall River Watershed</u>

While the mainstem level of fine sediments does not exceed standard (WFPB 1995), fine sediments are detrimental to salmon production in Fall River tributaries (Clark 1996).

Moss and Dean Creeks are tributaries that contain large quantities of fines. Both tributaries have naturally abundant fine sediment, but the level of fine sediment is worsened by mass wasting and surface erosion associated with roads (Clark 1996). The rate of mass wasting is relatively low in the Fall River sub-basin compared to nearby areas, with the exception of Moss Creek, which has large mass wasting problems (Clark 1996). Still, the amount of sediment from mass wasting sites and roads is a significant quantity throughout the remainder of the basin.

Mass wasting sites are the primary source of sediment, and 104 landslides have been identified in this region (Clark 1996). Most of the landslides are located in Moss Creek, Lower Fall River, and the Fall River headwaters. About 45% of these landslides are probably related to past non-road timber harvest activities, mostly located in Moss Creek. Since 1955, there has been a decreasing trend in landslides and sediment delivery from Moss Creek, Dean Creek, Boss Creek, and the Fall River headwaters (Clark 1996).

The second greatest quantity of sediment from non-natural sources is from roads, and about 40% of the landslides are associated with roads. Of particular importance are roads that cross streams, mainline roads, and midslope roads with sidecast construction (Fig F.1). Bench roads also deliver sediment, but at lessor quantities. Hillslope erosion contributes very little sediment to this watershed (Baitis and Clark 1996).

Spawning habitat in the mainstem is dispersed and usually located in constrictions and near logjams (LWD). Gravel was actively mined in the lower Fall River from the 1940s-1960s, which reduced available spawning habitat (Weyerhaeuser 1996). Presently, the best spawning areas are in the lower Fall River, upper Fall River, and in Moss Creek. Other small tributaries have abundant sand, and do not provide large areas for spawning (Weyerhaeuser 1996).

An associated problem with sediment transport and delivery is the lack of LWD throughout the sub-basin, and the lack of LWD is the greatest limiting factor for salmon production in this region. The current level of LWD is very low throughout the region. All sampled sites had less than 1 piece/channel width (Table F.1), and most of the current LWD is from logging debris and wood from recent bank erosion (Weyerhaeuser 1996). This is due to harvest of the riparian areas from 1930-1970 and from stream cleaning.

The lack of LWD in the tributaries allows fine sediment to readily transport to the mainstem, and prevents the sorting and trapping of coarse gravel needed for spawning. The confluence of the Fall River has large quantities of fine sediment which have settled in the low gradient area (Weyerhaeuser 1996).

Table F.1. In-Channel LWD in the Fall River Watershed (Weyerhaeuser 1996).

Sub-Basin	Pieces/Channel Width
Lower Fall River	0.4
Lower Fall River	1.8
Middle Fall River	1.9
Middle Fall River	0.2
Fall Headwaters	0.4
Moss Creek	0.82
Dean Creek	0.3
Pomona Creek	0.3
Pomona Creek	0.2
Boss Creek/Fall River	0.6
Boss Creek	0.7
Boss Creek	0.9

Streambed and Sediment Conditions in the Willapa River Watershed

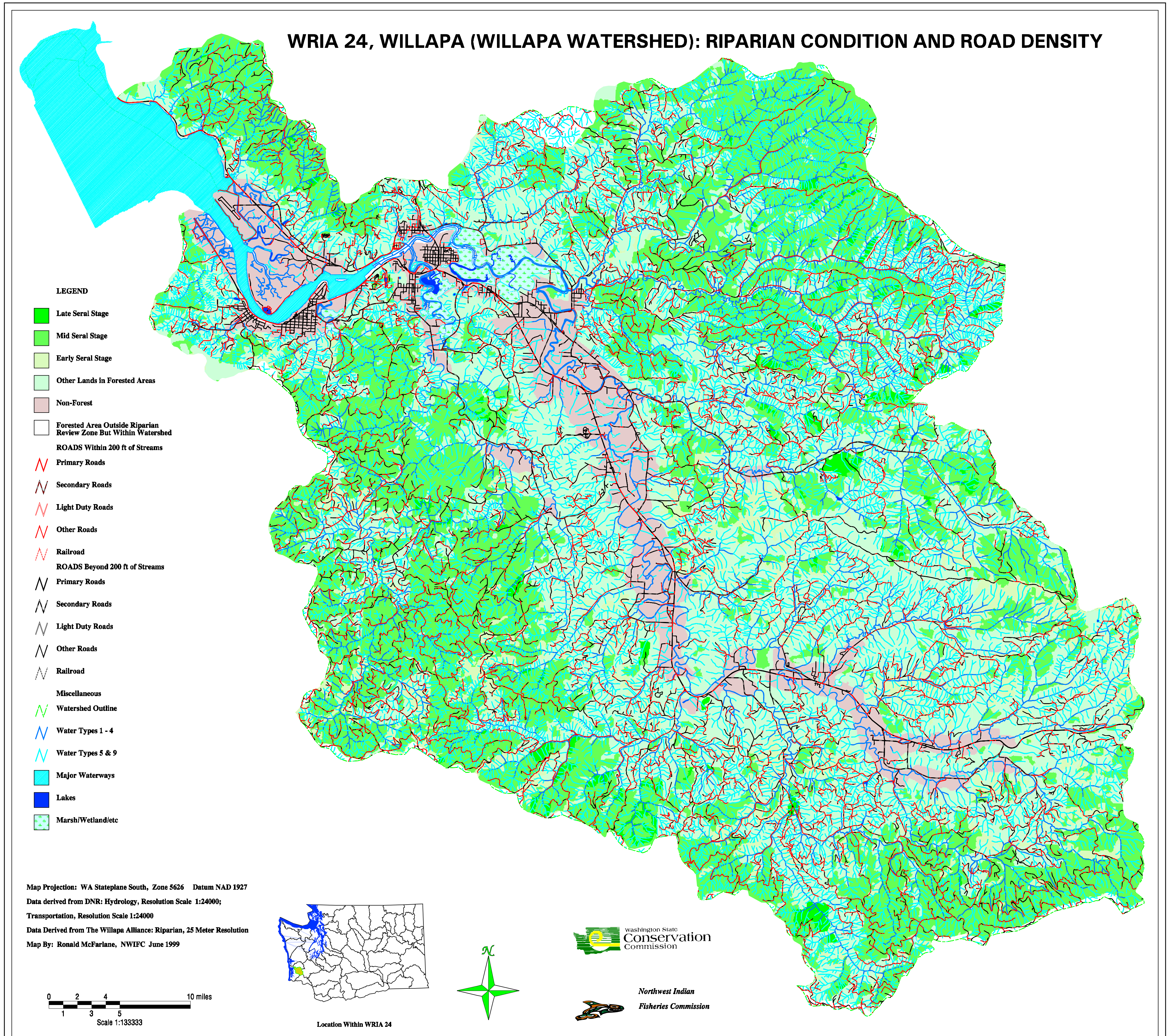
The mainstem upper Willapa River is dominated by bedrock with only patches of spawning gravel. The largest concentration of gravels in the upper mainstem is located just downstream of the confluence with Trap Creek for about 3 miles, along Elk Prairie Road to the confluence with Falls Creek. The southern tributaries have more spawning gravel than the northern ones due to geologic differences. However, the lack of LWD will continue to reduce spawning gravels. Current LWD counts are very low, ranging from 0.07-0.52 pieces/channel width (Hadley 1994). Watershed Analysis standards rate pieces/channel widths of less than 1 as “poor” (WFPB 1995).

Mass wasting is a major source of fine sediment, with 367 landslides were recorded in the upper Willapa Watershed. About 81% of these landslides were associated with roads, especially sidecast roads (uncompacted sidecast fill placed on steep slopes) (Laprade 1994). Non-road related landslides were associated with steep slopes which supplies gravel to the southern tributaries (Stringer, Trap, Forks, Ellis and Falls Creeks). Ellis Creek had the most landslides, while Penny Creek is the most stable (Laprade 1994). In Forks Creek, roads contributed significant levels of fines, particularly the mainline adjacent to the creek. Elsewhere, roads contributed sediment that was not considered to be a high impact, but could be improved at specific sites (Sullivan and Massong 1994).

There are over 465 miles of unpaved roads in the upper Willapa Watershed, which is an average density of 4.73 miles/square miles (Fig. F.2) (Laird 1994). The NMFS rated road densities of greater than 3 miles/square mile of watershed as “not properly functioning”; their highest level of impact (NMFS, 1995). Weyerhaeuser owns 214 miles of roads, DNR owns 91 miles, and the remainder is spread out to other timber companies. Pacific County and Washington State own less than 10 miles of roads and because they are paved, they contribute very little sediment (Laird 1994). Small private landowners own about 133 miles of road. The entire Willapa River Watershed has a high number of roads that cross streams (18 miles/square mile of watershed), and a high density of riparian roads, 3 miles/square mile of watershed (Fig. F.2) (The Willapa Alliance 1998).

The potential scour of chinook, coho, and chum redds is high based upon the analysis that bankfull flows (2-year recurrence interval) moves about 75-100% of the available bed materials (Hadley 1994). The confined nature of the mainstem and lack of LWD with these flows account for the cause of scour. Steelhead redds are less susceptible to scour because they spawn when such flows are uncommon.

Figure F.2. Road density and riparian vegetation type in the Willapa River Watershed (The Willapa Alliance 1998).



Streambed Sediment Conditions In The Palix Watershed

The availability of spawning gravels are limited to the Niawiakum River (lower reaches), the North Palix River, and the Middle Palix River. Of these, the Middle Palix (Canon River) has the greatest abundance of spawning gravel. Gravels are lacking in the Bone River and South Palix River, where the streambeds consist of silt. However, salmon use the Bone River and South Palix for juvenile rearing, particularly in the intertidal areas (Martin 1997).

About a third of the Palix watershed consists of basalt geology, which is capable of supplying fair spawning gravels. However, two processes impede the quality and quantity of spawning and incubation habitat in the Palix. One problem is the lack of sufficient sized LWD to sort and store good spawning gravel. The other significant problem is sedimentation.

High levels of fine (<0.841 mm diameter) sediment persist in Canyon Creek (13-33%) and the Palix headwaters (7-22%, mean = 15.4%), and are the result of roads and past splash damming (Dieu 1997). The road network is dense, ranging from 3.79 miles of roads/square miles of watershed in the lower Palix to 7.04 miles/square miles in the headwaters. The average road density is 5.68 miles/square miles in the WAU (Fig. F.3) (Graber and Gibbons 1997). The NMFS rated road densities of greater than 3 miles/square mile of watershed as “not properly functioning”; their highest level of impact (NMFS, 1995). Throughout the basin, roads contribute to sedimentation at stream crossings (10 crossings/square mile), and along riparian roads, which consist of 2 miles of roads/square mile of watershed (Fig. F.3) (The Willapa Alliance 1998).

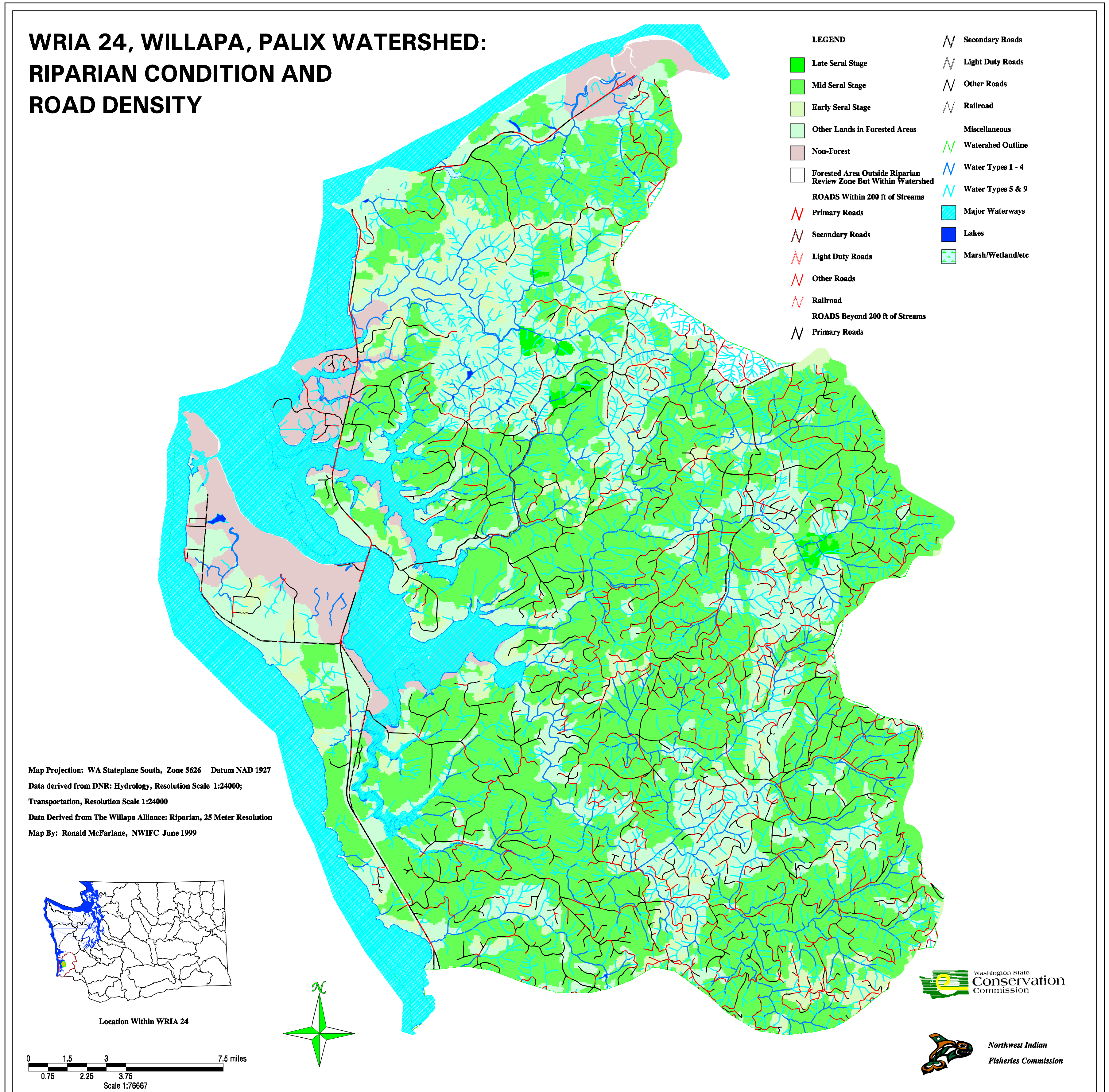
Currently, hillslope erosion and mass wasting are not large contributors of fine sediment in the Palix. Fine sediment levels are lower (9-11%) in the Middle Palix which supports much of the current salmon spawning production, but embeddedness surveys in those same areas indicated poor spawning gravel quality (Martin 1997).

Past logging practices still impact the rivers today. Early logging used steam donkeys and numerous splash dams. These practices reduced the levels of LWD, especially in the lower reaches of the rivers and in the Middle Palix River. These areas are low in key and functional LWD compared to the TFW target of 1/2 key piece/stream width and 2 functional key pieces/channel width. (They defined a key piece is 1' or greater in diameter, while a functional piece is less than 12" diameter.) Restoration projects have begun to address the LWD problem, but success of those projects is being evaluated. Restoration of LWD is a greater challenge in the Palix because of channel incision. For stability, larger pieces are needed (2’ or greater diameter) and attached rootwads would aid in stability (Tom Gibbons, DNR, personal communication).

The lower Middle Fork Palix is the best spawning area in the watershed. It is the only tributary that produces chinook salmon in the watershed, and also provides significant spawning habitat for chum and coho salmon as well as steelhead trout (Martin 1997). The Niawiakum and North Palix rated poor in current LWD, even including smaller pieces (Martin 1997).

Another result of splash damming and steam donkeys is downcutting of the channel due to scour. This has separated the channel from the floodplain, reducing juvenile rearing habitat, reducing material (such as LWD and leaf litter), and increases the risk of future scour because the river cannot dissipate flood energy by overflowing its banks. This will increase mortality of salmonid eggs, especially for species that spawn during or prior to winter high flows, such as chinook, coho and chum salmon. Steelhead may not be impacted as much because of spawn timing. Downcutting is a problem in the mainstem area from above the confluence of Canyon Creek to the mouth.

Figure F.3. Road density and riparian vegetation type in the Palix River Watershed (The Willapa Alliance 1998).

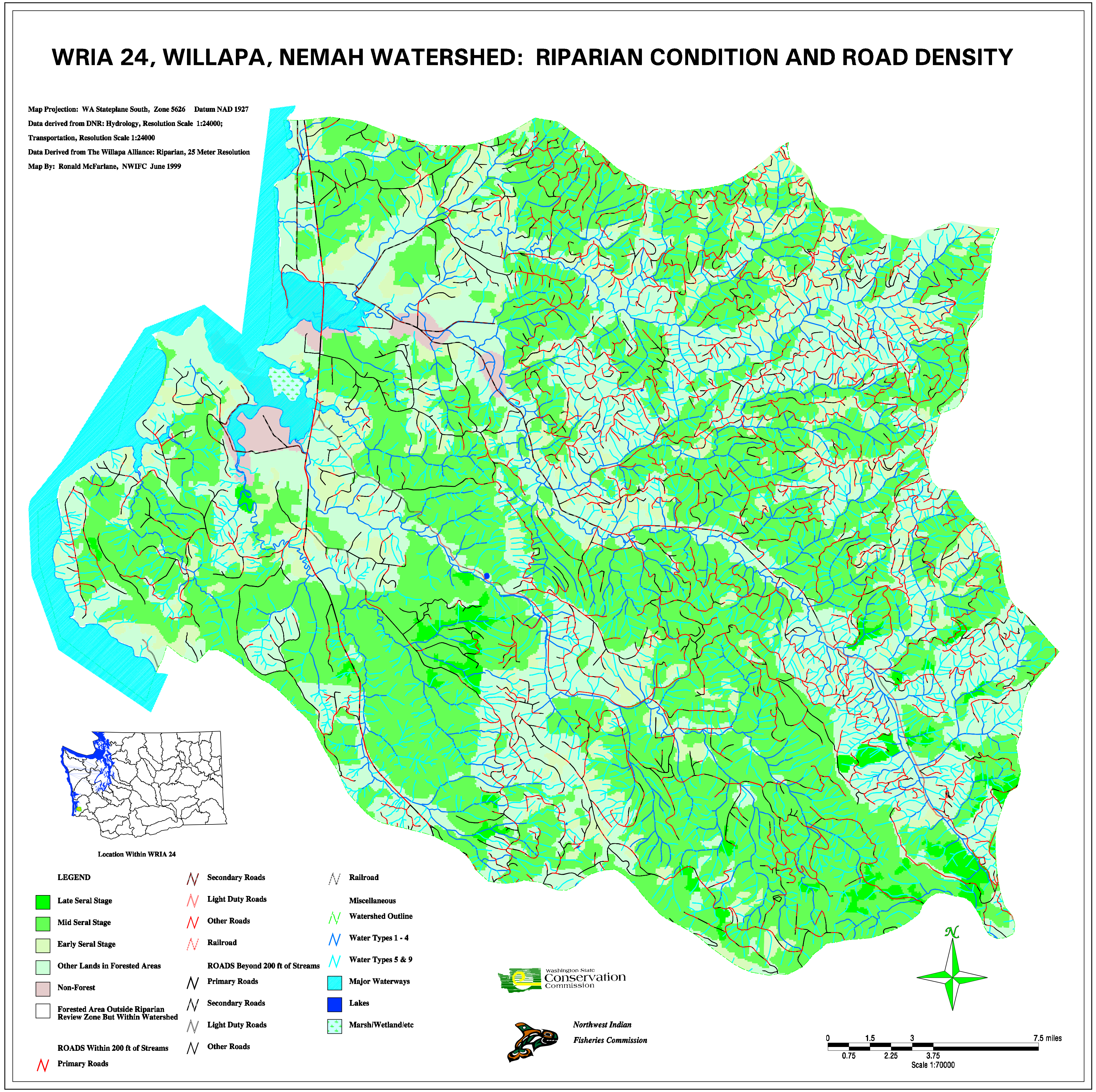


Streambed Sediment Conditions In The Nemah Watershed

Sedimentation is a major problem in the North and South Nemah Rivers, and roads are the major source of sediment. The road density is the second highest in the entire WRIA, 5.5 miles of roads/square mile of watershed (Fig. F.4). The NMFS rated road densities of greater than 3 miles/square mile of watershed as “not properly functioning”; their highest level of impact (NMFS, 1995). The Nemah Watershed has a large number of stream crossings (20 road stream crossings/square mile of watershed, or 146 crossings on Type 1-4 streams) (The Willapa Alliance 1998). The riparian area is impacted by 3 miles of riparian roads/square mile of watershed.

About 34% of the watershed consists of basalt geology, which over time, contributes good spawning gravels for salmon production, but gravel storage capability is poor due to low current levels of LWD. The larger (>12" diameter) key pieces are below target levels in 40% of the stream, while the smaller functional pieces are below target levels in 76% of the channels (PCD Salmon Habitat Survey 1997; The Willapa Alliance 1998).

Figure F.4. Road density and riparian vegetation type in the Nemah River Watershed (The Willapa Alliance 1998).

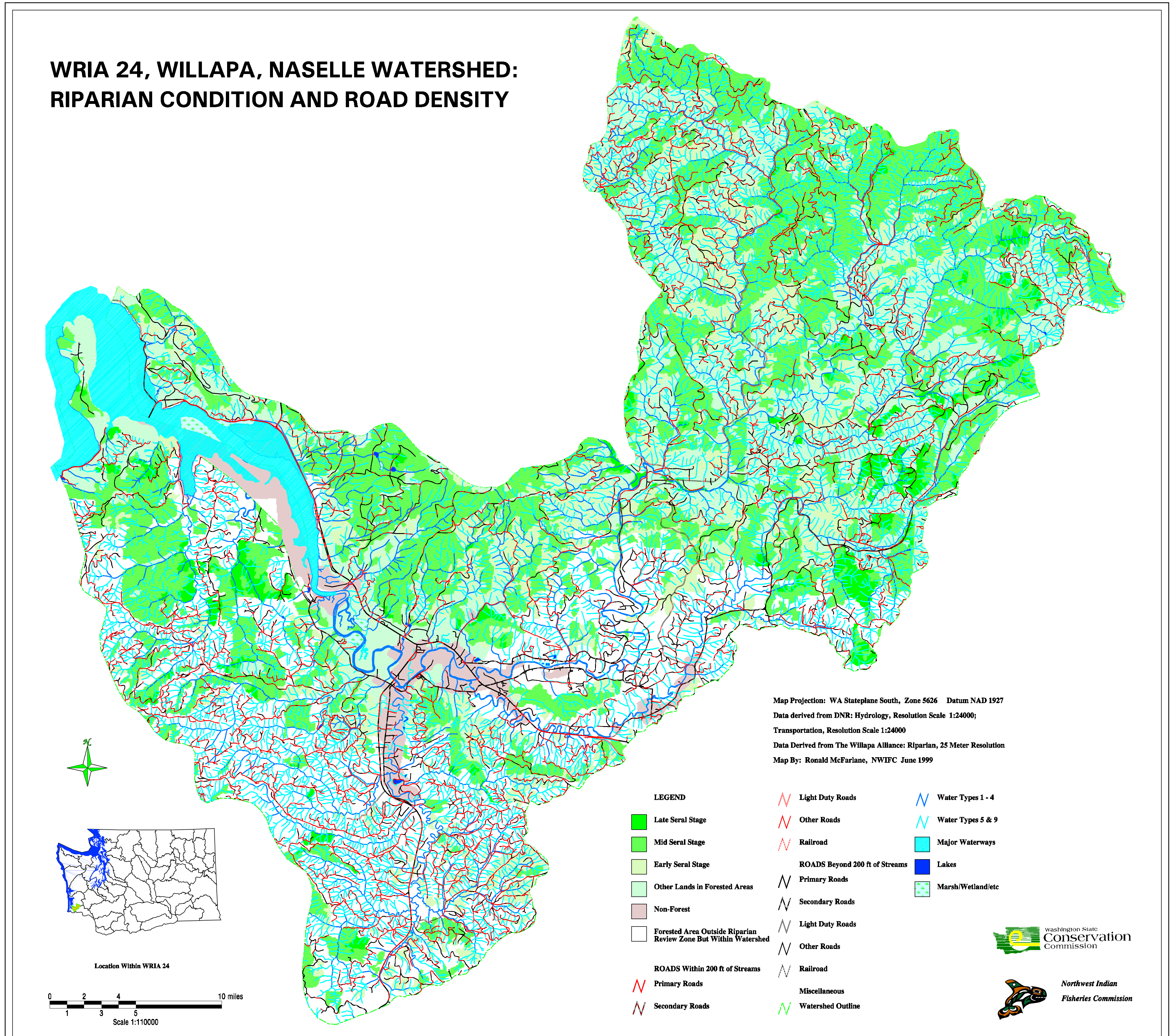


Streambed Sediment Conditions In The Naselle Watershed

Two major streambed/sediment problems exist in the Naselle watershed, excessive sedimentation and low levels of LWD. The greatest sources of sedimentation are from roads and mass wasting sites. The road density in the Naselle watershed is high, about 5.2 miles of roads/square miles of watershed (The Willapa Alliance 1998). Road densities of greater than 3 miles/square mile of watershed were rated as “not properly functioning” by the NMFS (NMFS, 1995). Road stream crossings are the highest in the WRIA with 20 crossings per square mile or 327 crossings on Type 1-4 streams, and riparian roads account for 3 miles of roads/square mile of watershed (Fig. F.5) (The Willapa Alliance 1998).

About 23% of the watershed consists of a basalt geology, capable of supplying good spawning gravels (The Willapa Alliance 1998). This is a moderate level of natural gravel recruitment potential. It is important to have good gravel storage capabilities to maintain salmon spawning habitat, but LWD, one of the most important gravel storage features, was found to be low in the sampled areas. About 92% of the sampled areas did not meet target levels of functional LWD pieces, and about 66% of the sampled areas did not meet target levels for key LWD pieces (PCD Salmon Habitat Survey 1997; The Willapa Alliance 1998). Restoring LWD pieces near sources of spawning gravel inputs would benefit salmon habitat in the Naselle, but care should be taken with LWD to engineer large pieces preferably with rootwads.

Figure F.5. Road density and riparian vegetation type in the Naselle River Watershed (The Willapa Alliance 1998).



Streambed Sediment Conditions In The Bear River Watershed

Major limiting factors to salmon production in the Bear River watershed include high levels of sedimentation and low levels of LWD. Sedimentation stems from mass wasting sites and secondarily from roads (Lebovitz 1998). The combination of mass wasting and a lack of LWD has led to debris flows that have downcutted and scoured stream channels (Lebovitz 1998). This downcutting has separated the channel from the floodplain, reducing salmon rearing habitat and ecosystem processes and increasing egg mortality through scour. Debris flows have also contributed to the further loss of LWD.

Roads have been identified as the second greatest contributor of sediment in the Bear River (Lebovitz 1998). About 4.9 miles of roads per square mile of watershed have been constructed, a fairly high road density (Fig. F.6) (The Willapa Alliance 1998). This is well above the “not properly functioning” level of 3 miles/square mile of watershed as rated by The NMFS (NMFS 1995). Of these roads, 465 cross Type 1-4 streams, and the greatest forest road sediment sources are parts of the Bear Mainline Road and Brix Road (Lebovitz 1998). The Spyder Creek Bridge abutment is also a significant sediment producer.

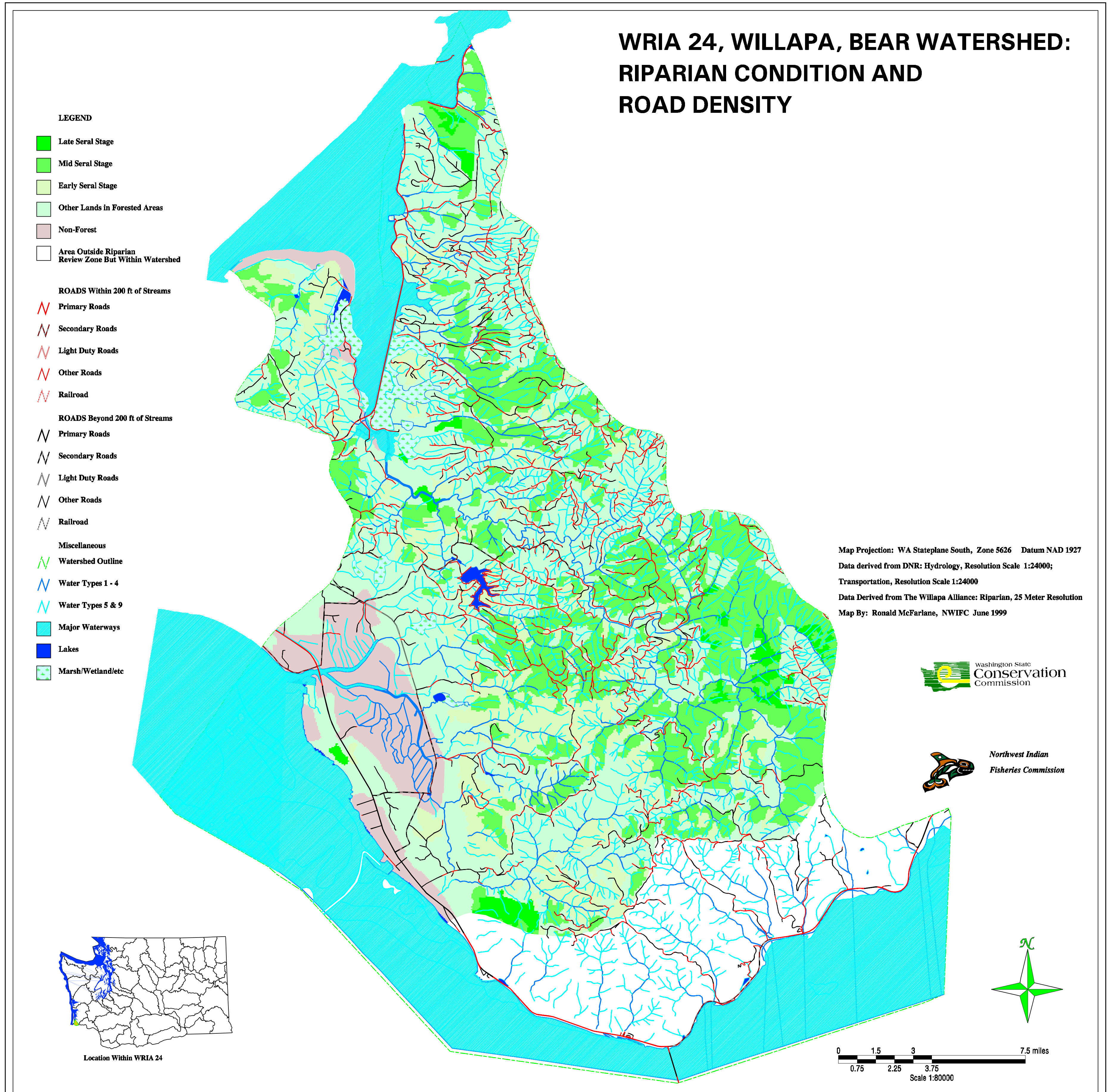
The density of roads in the riparian areas is the highest in the WRIA, with about 3.2 riparian roads per square mile of watershed or 90 miles of riparian roads (The Willapa Alliance 1998). This not only reduces the forest vegetation in the riparian area, but also serves as potential sediment sources and can act as dikes.

Current levels of LWD are low due to mass wasting debris flows, past logging practices, and "stream cleaning" efforts in the 1970s. About 47% of the watershed did not meet target levels for key pieces of LWD and about 51% of the watershed did not meet target levels for functional LWD pieces (PCD Salmon Habitat Survey 1997). Because of the low level of basalt geology (18% of the watershed), spawning gravel recruitment can be a problem. The low levels of LWD greatly compound the gravel recruitment problem. Recent restoration effects have occurred in the upper Bear River, but future restoration needs to be targeted to the lower reaches. Reaches deficient of LWD are 1) the reach from Taylor Bridge to 1 mile downstream, 2) between Taylor Bridge and the second bridge in Section 27, 3) the headwaters of Spyder Creek 4) from the mouth of Spyder Creek to the second bridge, and 5) in the headwaters of Bear River downstream of the Brix Road bridge (Lebovitz 1998).

Data Needs For Streambed Sediment Conditions In WRIA 24

- Sediment budgeting (as done in Watershed Analysis) is needed throughout the basin.
- Hauling (from trucks) impacts need to be better monitored.

Figure F.6. Road density and riparian vegetation type in the Bear River Watershed (The Willapa Alliance 1998).



G) RIPARIAN CONDITIONS IN WRIA 24

Riparian Zone Functions

Stream riparian zones are the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the average high water mark of the wetted channel toward the uplands to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the drainage network. For example, fires, severe windstorms, and debris flows can dramatically alter riparian characteristics. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin unimpacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Functions of riparian zones include providing hydraulic diversity, adding structural complexity, buffering the energy of runoff events and erosive forces, moderating temperatures, and providing a source of nutrients. They are especially important as the source of large woody debris (LWD) in streams which directly influences several habitat attributes important to anadromous species. In particular, LWD helps control the amount of pool habitat and can serve as a site for sediment and nutrient storage. Pools provide a refuge from predators and high-flow events for juvenile salmon, especially coho that rear for extended periods in streams.

Effects of Human Activities on Riparian Zones

Riparian zones are impacted by all types of land use practices. In general, riparian forests can be completely removed, broken longitudinally by roads, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when native, coniferous trees are replaced by exotic species, shrubs, and deciduous species. Deciduous trees are typically of smaller diameter than coniferous forests and decompose faster than conifers, so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover regrows, and coniferous species colonize.

Changes to riparian zones affect many attributes of stream ecosystems. For example, stream temperatures can increase due to the loss of shade, while streambanks can become more prone to erosion due to elimination of the trees and their associated roots. Perhaps the most important impact of riparian changes is a decline in the frequency, volume and quantity of LWD due to altered recruitment from forested areas. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces the number of rearing salmonids. Loss of LWD affects the amount of both overwintering and low flow rearing habitat as well as providing a variety of other ecological functions in the channel.

Riparian Conditions In The North River Watershed

The riparian area throughout the North River watershed is generally better than other watersheds within WRIA 24 (Fig. F.1). A greater percentage of older conifers (63% of mid-seral to mature) exists (The Willapa Alliance 1998), but that percentage is still inadequate for future target levels of LWD. This limits salmon production in this watershed through a lack of pools and spawning gravel retention. The poorer areas of North River riparian include the middle and upper mainstem North River, the Little North River, which is dominated by deciduous stands, and the Vesta Creek drainage. The Vesta Creek riparian area is a single age watershed with young (<40 years), dense conifers forming about 37% of the total riparian miles in the watershed (Jordan 1995).

One important function of the riparian area is to supply LWD to the stream. In many surveyed areas of the lower watershed, LWD levels were found to be high (45% of sampled sites) (Herger 1997) based upon Watershed Analysis Manual (WFPB 1995). Much of this was old logging debris. About 19% were rated "medium" in LWD quantity, and 35% rated "low". However, the future levels of LWD do not appear to be adequate. These same areas have low near-term wood recruitment potential (Fig. G.1) (Herger 1997). Most of the sampled sites were in the smaller streams; the lower mainstem was not included in this rating. Low levels of LWD also reduce the available cover for migrating adults as well as juveniles who are rearing or migrating.

In the Little North River and Vesta Creek watersheds, current wood in the channel is lower than target levels and ranges from 0.2-1.6 pieces/bankfull width (Peacock 1995). Most of the current LWD is re-exposed burned wood that was buried after the 1930s fires (Clark 1995). The low gradient streams limit the transport of wood so that the distribution is poor. The high sediment inputs (see Streambed section) tend to bury wood as well, reducing its functional value.

Also, there is low potential near-term and long-term LWD recruitment along the Little North River, which has the largest concentration of dense mature deciduous stands (alder) that will be unable to supply adequate LWD. The mainstem North River has areas with mature deciduous stands as well as cleared areas for agricultural and residential use near the confluence with the Little North River. Along this middle region of the North River, 78% of the areas were rated as low in near-term LWD potential, with 54% in agricultural or other non-forest lands (Clark 1995). Salmon and Vesta Creeks also rated low in near term LWD recruitment potential, although Vesta rated higher than the other areas with 16% of high near-term LWD recruitment potential. Only 20% of the total stream miles were rated as good long-term LWD recruitment potential (Jordan 1995). Although riparian restoration projects cannot address near-term LWD recruitment potential, they can improve the long-term potential through replanting cleared riparian areas and replacing deciduous areas with conifers. This type of restoration project must be done carefully, because removal of large deciduous trees in the riparian could increase water temperatures.

Throughout the North River Watershed, LWD is the primary pool-forming element. In the smaller tributaries to the lower North River, pool habitat was moderately abundant with 68% of the segments rated as "medium"(Herger 1997). However, no sampled segments were rated as "high" and 32% were rated as "low" (Herger 1997). In these same areas, pool depth averaged 50-60 cm, and cover (wood) within pools was rated as 0% "high", 58% medium, and 42% low (Herger 1997). Some of these smaller tributaries also have beaver complexes within them, which can contribute to deep water habitat important for winter rearing, but these can also impede migration.

From RM 26-46.5, the mainstem North River has abundant low velocity, deep-water reaches with few deep pools (Herger 1995). Of greater concern is a lack of cover (LWD), overhanging banks, and adequate shade (leading to temperature concerns). High levels of fines have also filled pools in this region, and combined with low riparian shade, reduces rearing habitat and potentially increases water temperatures (Clark 1995).

Pool habitat in the Little North River and Vesta Creek drainages is limited because of fine sediment fill, and lack of LWD (Clark 1995). Up to 70% of the pools were filled with sediment (Peacock 1995). This limits the rearing potential for coho salmon and steelhead trout. The high gradient small tributaries in the headwaters contain more wood, have better cover, and have better bank stability.

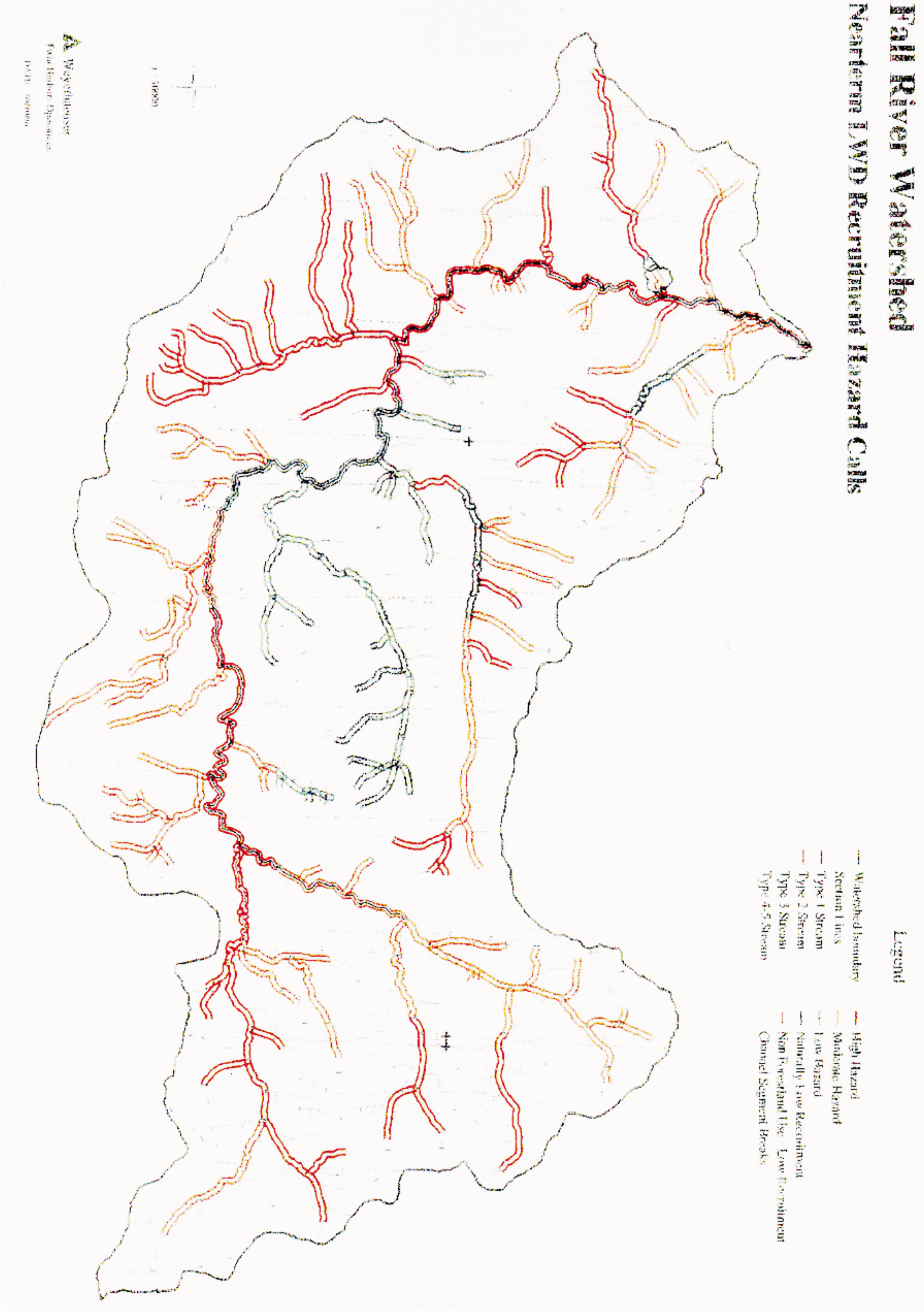
Riparian Conditions In The Fall River Watershed

The Fall River riparian is impaired. Near-term recruitment of LWD is poor throughout much of the watershed (Fig. G.1) (Light and Beach 1996). The exceptions to this are a middle segment of the Fall River, Pomona Creek, lower Dean Creek, and middle Moss Creek. The lower segment of the Fall River has been converted to agricultural lands, but that same area has a naturally low LWD potential. Historically, the lower 2-3 miles of mainstem was dominated by small to moderate hardwoods, but upstream of RM 3, large conifers comprised the historic riparian (Light and Beach 1996). Dean and Moss Creeks' riparian zones are similar to historic conditions based upon the low density of stumps in the riparian areas.

Long-term LWD recruitment is better than near-term and is moderate to high for much of the watershed (Light and Beach 1996). Only about 9% of the riparian area is rated as having a low long-term LWD recruitment, whereas 53% is rated as high and 19% rated as moderate (Light and Beach 1996). The areas of low long-term recruitment potential are comprised of alder stands as a result of previous vegetation disturbance.

In the mainstem Fall River and larger tributaries, the LWD count averaged less than 1 piece/channel width, well below the Washington Forest Practices Board (1995) indices of 1-2 pieces/channel width for fair habitat quality and >2 pieces for good habitat quality (Herger 1996). Also in these areas, pool frequency ranged from 22-44% (Herger 1996), below the "good" habitat target of >55%. The low pool frequency is related to low levels of LWD. Pool depths were also noted as inadequate (Herger 1996).

Figure G.1. Fall River Watershed Near-Term LWD Recruitment Potential (Weyerhaeuser)



Riparian Conditions In The Willapa River Watershed

Only 42% of riparian acres consists of mid-seral to mature conifer stands (Fig. F.2) (The Willapa Alliance 1998). Of this, about 2% consist of late seral to mature conifers. The mainstem Willapa River is severely impacted (Fig. F.2), and because all salmonid production in this watershed depends upon good mainstem habitat, the impact is considerable. In the upper Willapa River, current levels of LWD are low with three exceptions: one area of old-growth in Ellis Creek, one area of Trap Creek, and one area in Silver Creek (Hawe and Fulton 1994). The lack of current LWD and the poor future LWD recruitment is the greatest impact to salmon production in this watershed.

Only about 7% of the upper Willapa River was rated as good near-term LWD recruitment potential (Hawe and Fulton 1994). About 65% was rated as fair, and 28% rated as poor near-term LWD recruitment potential. Previous logging activity and agricultural conversion has removed mature conifers along the mainstem Willapa River, and upper Stringer, Trap, Half Moon, Penny, Patton, and Ellis Creeks. Currently, LWD recruitment will be inadequate for about 140 years in these areas.

Pools are infrequent, shallow (few exceeding 1 meter at low flow) and widely spaced and limit rearing habitat for coho, winter steelhead, and fall chinook (Hadley 1994). Overhead cover and LWD are also lacking. In the northern tributaries, pools fill with the high sediment levels. In the mainstem Willapa River, the river has incised and reached bedrock, resulting in few pools (combined with little LWD) (Sullivan and Massong 1994). In the summer, flows are low and high temperatures further impact summer rearing (see the Water Quality chapter). The best summer rearing habitats are: Stringer Creek, lowest 2-3 miles of Trap Creek, Forks Creek, parts of Ellis Creek, and lower Walker Creek (Hadley 1994). However, many of these same areas (Stringer, Ellis, Trap, Forks) in addition to the upper mainstem Willapa and Falls Creek, have large scour and deposition events in the winter. Although these channels are naturally confined with few side channels and backwater areas, the lack of LWD increases the stream velocity creating in-channel scour. Walker Creek has good winter habitat with off-channel rearing, deep pools with LWD.

Riparian Conditions In The Palix Watershed

Less than 1% of the Palix River riparian is in the late seral or mature stage, 56% is intermediate, 8% young conifer stage, and the remainder is either open or dominated by hardwoods (Fig. F.3) (The Willapa Alliance 1998).

Current levels of LWD (greater than 60 cm diameter), are low throughout most of the watershed, especially in the estuarine/intertidal areas and the lower freshwater reaches. Some headwater reaches have adequate in-channel LWD (Bretherton and Cahill 1996). Near-term LWD recruitment potential is a serious concern for salmon production, particularly in the Middle Palix mainstem, much of the North Palix mainstem, and scattered headwater reaches (Bretherton and Cahill 1996). For Type 1-2 streams, 24% were rated as poor, while for Type 4 streams, 48% were rated as poor. The low near-term LWD recruitment will continue to impact numerous salmon production processes, such as quantity of spawning habitat, pools for migrating adults and rearing juveniles, and for hydrologic stability. The long-term LWD recruitment potential is relatively good due to conifer stocking and the high percentage of intermediate stage riparian forests.

There are about 2 miles of riparian roads per square mile of watershed. These roads impact the riparian area, reducing LWD recruitment and potentially contributing to sedimentation as well as separation from the floodplain.

The amount of pool habitat ranges from 43-62%, and is rated as good for most sampled areas (Martin 1997). However, the spacing of pools was rated as fair to poor, which would impact juvenile rearing habitat for coho and steelhead.

Riparian Conditions In The Nemah Watershed

Most (68%) of the riparian consists of early conifers and hardwoods. About 34% were classified as mid-late seral stage and 1% as mature (Fig. F.4) (The Willapa Alliance 1998). Recruitment potential for LWD has not been calculated, but these estimates suggest that near-term recruitment would likely be low.

Current levels of LWD are below target for both key pieces (40% of the watershed below target) and functional pieces (76% of the watershed below target) (PCD Salmonid Habitat Survey 1997).

Another riparian impact is the quantity of roads in the riparian area. About 3 miles of riparian roads per square mile have been constructed in the Nemah watershed. These roads could impact the stream in several ways. They reduce the available forest vegetation, are potential sediment sources, and if constructed close to the stream, act as dikes, contributing to scour and channel instability.

Riparian Conditions In The Naselle Watershed

The riparian zone currently consists of about 9% old growth, 47% mid-late seral stage forest, and 44% open, early conifer, or hardwood dominated forests (Fig. F.5) (The Willapa Alliance 1998).

The current levels of LWD, one of the most important pool-forming features, were found to be low in the sampled areas. About 92% of the sampled areas did not meet target levels of functional LWD pieces, and about 66% of the sampled areas did not meet target levels for key LWD pieces (PCD Salmonid Habitat Survey 1997).

Another riparian impact is the quantity of roads in the riparian area. About 3 miles of riparian roads per square mile have been constructed in the Nemah watershed (The Willapa Alliance 1998). These roads could impact the stream in several ways. They reduce the available forest vegetation, are potential sediment sources, and if constructed close to the stream, act as dikes, contributing to scour and channel instability.

Riparian Conditions In The Bear River Watershed

The Bear River riparian zone consists of 2% old growth or mature, 34% mid-late seral stage forest, and 64% young conifer, open, or hardwood dominated (Fig. F.6) (The Willapa Alliance 1998). This is a significant conversion from the historic old growth conifer dominated forest. These riparian conditions result in low near-term LWD recruitment. Long-term LWD recruitment is moderate due to restoration projects.

Current levels of LWD are low. About 47% of the watershed did not meet target levels for key pieces of LWD and about 51% of the watershed did not meet target levels for functional LWD pieces (PCD Salmonid Habitat Survey 1997). Pooh habitat is below target, limiting coho salmon and steelhead trout production (The Willapa Alliance 1998).

Riparian roads also impact the riparian area and consist of 3.2 miles of riparian roads per square mile of watershed (The Willapa Alliance 1998). These roads reduce forest vegetation, contribute to sedimentation, and in some cases, act as dikes along the stream banks.

Data Needs

- Comprehensive habitat surveys are needed throughout the basin. This includes detailed analysis of LWD, pools, riparian, and substrate.

H) WATER QUALITY IN THE WILLAPA BASIN

Water Quality In The North River Watershed

Limited water temperature data were collected in the North River Basin in 1978, 1979, and 1992 and summarized by The Willapa Alliance (1998). These data indicate that high water temperatures are a problem in the North River Basin. In the months from May through September, 4 out of 6 samples from June through August measured water temperatures at or higher than 16 ^{o} C. One of those samples exceeded the Class A maximum allowable temperature standard (WAC 173-201A-130) of 18 ^{o} C. All of the temperature exceedances occurred in 1992. These same data showed that average stream dissolved oxygen (DO) was adequate at 10 mgl, with no records of stream DO less than 7 mgl (The Willapa Alliance 1998).

Additional water quality data for various sub-basins within the North River were available in watershed analyses, and those results are summarized below.

<u>Lower North River and Salmon Creek</u>

Water temperature was recorded using continuous recording thermographs at six sites within the lower North River basin anadromous zone during the summer, 1996 (Herger 1997). In all of the sampled sites, water temperature exceeded the 18 ^{o}C State water quality criterion for Type A waters (Table H.1, Herger 1997). In three of the sites (North River segment 6, North River unnamed tributary, and Joe Creek), the water temperature exceeded 20 ^{o} C for 5, 14, and 9 days, respectively. Water temperatures in this range over a period of weeks can result in death for salmonids due to interaction with other stresses such as disease (Gregory et al. 1994).

In addition, the Shoalwater Indian Tribe submitted data to the Washington Department of Ecology (DOE) in which 18 out of 21 samples in the mainstem lower North River (RM 28) exceeded 18 ^{o} C in August, 1997 (DOE, 1998). Again, these temperatures can result in death for salmonids over an extended period. Because of these temperature exceedances, Joe Creek, the East Fork North River, the unnamed North River tributary, and mainstem North River (TRS 16N, 08W, 09) are now on the 1998 303(d) Candidate List (Fig. H.1) (DOE 1998). Salmon Creek was also submitted as a candidate for the 303(d) List, and one upper section (TRS 16N, 08W, 09) still remains on the list because 13 out of 21 samples exceeded temperature standards in 1997 (DOE 1998).

Table H.1. Water Temperature Data from the Lower North River (Herger 1997)

Location	Maximum temperature	Days >18 ^{o} C
North River Segment 6	26	33
North River Segment 8	21.1	25
North River Tributary 16N, 09W, 33	21.9	28
Joe Creek	21.9	34
Salmon Creek Seg. 10	18.8	3
Salmon Creek Seg. 11	19	5
EF North River	20	5

Most of the Lower North River mainstem, Lower Salmon Creek, North Branch, East Fork North River, and Joe Creek were rated as low in riparian shade, which would stress summer rearing and migrating salmon with higher temperatures, as well as provide less ecosystem benefits such as leaf litter and insects. It is believed that the North River is capable of 60% shade levels (pre-harvest conditions would have produced a canopy that would have shaded 60% of the stream channel, based upon photo interpretation) (Herger 1997). Several of the small tributaries had good canopy cover providing adequate shade (Herger 1997). Of the 156 stream miles assessed (most of these were small tributaries), 46% had at or above target shade and 31% had below target levels (Herger 1997). The remaining stream miles have naturally low shade levels, and much of this was in the lower North River where it is wider than 100' at low flow.

Another water quality problem in the lower North River mainstem and Lower Salmon Creek is turbidity during winter storms (Herger 1997).

Smith Creek

Smith Creek was placed on the 1998 303(d) Candidate List due to high water temperatures (Fig. H.1). This was based upon 27 samples that exceeded 18 ^{o} C in 1988 (DOE 1998). Temperatures in this range can cause death in salmonids over an extended period, due to interaction with other stresses such as disease (Gregory et al. 1994).

Elkhorn Creek is a major tributary to Smith Creek and is on the 1998 303(d) Candidate List because of high water temperatures (DOE 1998). The Shoalwater Indian Tribe submitted data that showed 18 out of 21 samples at RM 1.5 exceeded the water quality standard of 18^{o}C in August, 1997.

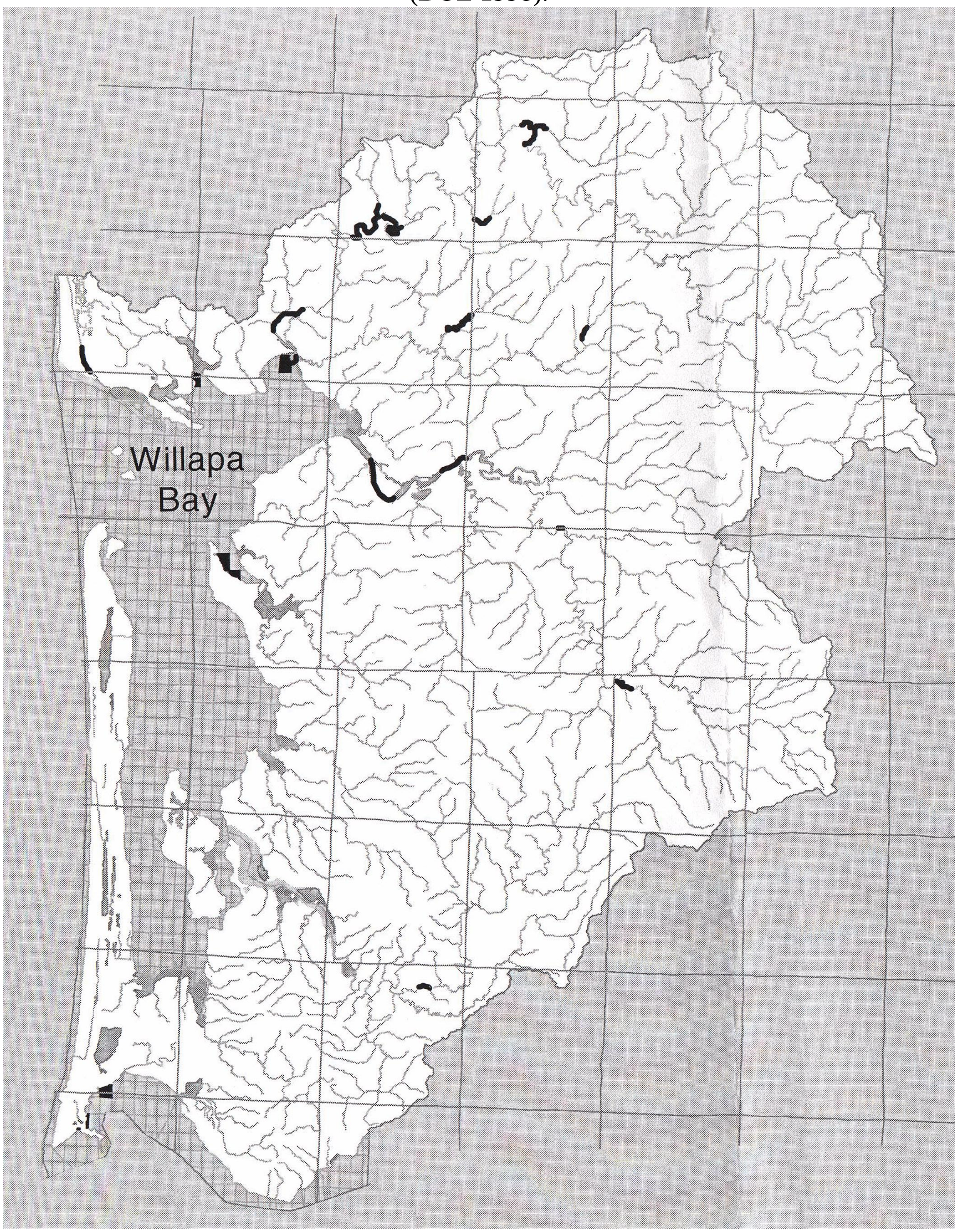
Little North River And Vesta Creek

Three segments of the Little North River are on the 1998 303(d) Candidate List because of high water temperatures (Fig. H.1) (DOE 1998). The three sections are at RM 0.1, south of New Lund Road, and at the spur road off of the C-Line.

Even though shade conditions have improved from 1967 to 1994 (aerial photograph comparison), about 38% of the stream miles in these sub-basins do not meet shade requirements (Clark 1995). Within this area, 78% of the North River mainstem stream miles do not meet shade requirements because of sparse alder stands and the predominance of agricultural and rural development areas that have cleared away the riparian vegetation. Land use in the riparian areas consists of 55% agriculture/rural development and 45% forestland (Jordan 1995).

About 80% of Salmon Creek and its tributaries do not meet shade requirements (Clark 1995). In the Vesta Creek region, shade levels are low, but some areas have been replanted with Douglas fir and those have not yet matured to provide adequate shade levels. The Little North River riparian area is among the best in the sub-basin, but still shade levels are low (Clark 1995).

Figure H.1. Darkened areas are segments on the 1998 Section 303(d) Candidate Waters List (DOE 1998).



In the summer, low levels of dissolved oxygen (DO) may be a problem in areas with low water velocity and high inputs of organic debris. Beaver dam areas may be particularly prone to this problem (Herger 1995).

Fall River

In a recent assessment of about 53 miles of stream, about 63% of the streams in the Fall River Watershed met or exceeded target shade levels, 7% were indeterminate, and 29% were below target (Light and Beach 1996). In about 7% of the streams, there is naturally low shade. Most of the tributaries have moderate to high shade levels (Herger 1997). However, the middle mainstem area from RM 2-5, as well as around Pomona Creek and stream 24.0203, there is low shade which can contribute to high temperature problems in the summer months, especially for adult chinook migrating to spawning areas and steelhead and coho juvenile rearing.

Water Quality In The Willapa River Watershed

The Willapa River is currently listed under section 303(d) of the Clean Water Act, and water quality problems are significant problems for salmon in terms of high summer temperatures and low dissolved oxygen. The mainstem Willapa River has been identified as "water quality limited" in temperature. Annual peak water temperature at the Department of Ecology's monitoring station (WA -24-2030) near Lebam has 7 years of violations over a 14 year period (Hawe and Fulton 1994). Listed segments are shown in Figure H.1. Table H.2 summarizes past water temperature data collected from 1959-1961 and from 1965-1991 (The Willapa Alliance 1998). From these samples, water temperatures were especially high from July through September, which could impact adult chinook salmon migration and spawning as well as coho and steelhead juveniles. Temperatures above 18 ^{o}C over a few weeks, can result in salmonid mortality (Gregory et al. 1994). Temperatures above 23 ^{o}C can directly cause salmonid mortality with much less exposure (Bjornn and Reiser 1991).

For dissolved oxygen (DO), about 9% of the samples fell below 7 mgl, and the average stream DO was 9.9 mgl (Willapa Alliance 1998). The Washington Department of Ecology is conducting a TMDL (total maximum daily load) study in the Willapa. Data collected near Raymond show that while DO has a strong inverse relationship to temperature and salinity, it is also depressed by other factors (Pickett 1999). DO levels are more likely to fall below State standards in May, July, and August at Johnson Slough, in July at Willapa, in July, August, and September near Raymond, and in August at Lebam (Pickett 1999). While this could impact adult chinook returning to spawn, it can also impact most juvenile salmonids in this area.

In the upper Willapa River, about 30% of the sampled areas did not meet target shade levels, which resulted in peak summer water temperatures often exceeding 18 ^{o}C and sometimes even 22 ^{o}C (Hawe and Fulton 1994). The areas of concern include all of the upper mainstem Willapa, along with significant areas of Green, Half Moon, upper Trap, Forks, Fern, and Penny Creeks. About 51% of the temperature problem sections in the upper Willapa basin flow through agricultural lands. Many of these areas lack an adequate riparian zone.

Table H.2. Water Temperature Exceedances in the Willapa River (The Willapa Alliance 1998)

Month	Percent Samples $\geq 16^{o}$ C	Percent Samples $\geq 18^{o}$ C
May (n=110)	9%	0%
June (n=118)	48%	18%
July (n=116)	84%	53%
August (n=135)	81%	35%
September (n=105)	46%	24%

Water Quality In The Palix Watershed

In the summer of 1996, water temperature and shade were assessed for watershed analysis, and based upon those measurements, the author concluded that high summer water temperatures did not appear to be a problem in the Palix, Niawiakum, and Bone Watersheds (Martin 1997). Table H.3 provides a summary of those results.

Table H.3. Shade and Water Temperature in the Palix WAU (Martin 1997). All temperatures were measured in July or August daylight hours. Shade was estimated with 1993 aerial photographs.

Sub-basin	Shade	Temperature ^{o}C
Bruceport	Open	NA
Bone River	Partly Shaded-Shaded	NA
Niawiakum	37-94%	13-14
Nichols Creek	Open to 41%	13-15.5
North Palix	57%-Shaded	13-14.5
Middle Palix	86%-Shaded	12-13
Canyon Creek	8-90% avg=56.6	12-13
Palix Headwaters	Open-Mostly Shaded	NA
South Palix	Open	NA
Pickernell Creek	Mostly Shaded	12.5

Water temperature in the Bruceport and Bone River Basins is controlled by interactions with riparian marshlands upstream, and tidal and estuary influences in the lower reaches. The lower reaches are naturally unshaded.

Water Quality In The Nemah Watershed

In the Nemah watershed, water temperature data are very limited, with small collections from 1973 and 1976-1977. These are summarized in Table H.4 and indicate that additional temperature monitoring is needed (The Willapa Alliance 1998). Dissolved oxygen was not a problem, averaging 10.7 mgl, with no samples falling below 7 mgl (The Willapa Alliance 1998).

Table H.4. Water Temperatures in the Nemah River (The Willapa Alliance 1998)

Month	Percent Samples>16°C	Percent Samples≥18°C
May (n=13)	0%	0%
June (n=14)	0%	0%
July (n=17)	6%	6%
August (n=12)	33%	0%
September (n=14)	14%	0%

Water Quality In The Naselle Watershed

In 1988, Naselle River stream temperature measurements were all below 18 °C with maximum temperatures of 16 °C in August (Sullivan et al. 1990). However additional water temperature data illustrate that high water temperatures can be a problem for salmon in the Naselle River Basin, particularly in July and August (Table H.5) (The Willapa Alliance 1998). Temperatures in these ranges can increase salmonid mortality (Gregory et al. 1994). These data were collected from 1966-67, 1969-70, 1973, 1976-79, and 1992, and because of the low sample sizes and conflicting results with the 1988 data, additional water temperature monitoring is needed. One segment of the upper Naselle has been listed on the 1998 Section 303(d) Candidate Waters List for temperature (Fig. H.1). Dissolved oxygen averaged 11.2 with no measurements falling below 7 mgl (The Willapa Alliance 1998).

Table H.5. Water Temperatures in the Naselle River (The Willapa Alliance 1998)

Month	Percent Samples>16°C	Percent Samples≥18°C
May (n=17)	18%	6%
June (n=16)	19%	6%
July (n=17)	71%	53%
August (n=10)	50%	20%
September (n=17)	41%	6%

Water Quality In The Bear River Watershed

Very few water temperature data were available for the Bear River, and additional monitoring is needed. Existing data were collected in 1973 and 1976-1977, and are summarized in Table H.6 (The Willapa Alliance 1998). Dissolved oxygen averaged 10.7 with no measurements falling below 7 mgl (Willapa Alliance 1998).

Table H.6. Water Temperatures in the Bear River (The Willapa Alliance 1998)

Month	Percent Samples>16°C	Percent Samples≥18°C
May (n=6)	17%	0%
June (n=6)	0%	0%
July (n=7)	14%	14%
August (n=5)	60%	40%
September (n=4)	0%	0%

Data Needs For Water Quality Issues In The Willapa Basin

- Comprehensive monitoring of summer temperatures and dissolved oxygen is needed for all watersheds within the WRIA 24, especially in the Naselle River, where existing limited data indicate water temperature problems for salmonids.

I) WATER QUANTITY ISSUES IN THE WILLAPA BASIN

Introduction

The hydrologic regime of a drainage basin refers to how water is collected, moved and stored. The frequency and magnitude of floods in streams are especially important since floods are the primary source of disturbance in streams and thus play a key role in how they are structured and function. In ecologically healthy systems, the physical and biotic changes caused by natural disturbances are not usually sustained, and recovery is rapid to predisturbance levels. If the magnitude of change is sufficiently large, however, permanent impacts can occur.

Alterations in basin hydrology are caused by changes in soils, decreases in the amount of forest cover, increases in impervious surfaces, elimination of riparian and headwater wetlands, and changes in landscape context. Hydrologic impacts occur even at low levels of development (<2% impervious surfaces) and generally increase in severity as more of the landscape is converted to urban or open uses.

Water Quantity Problems In The North River and Salmon Creek Watersheds

This region has very little rain-on-snow area, and peak flows are driven by rainfall (SCS 1986). The greatest volume of rainfall is between October through February. The age and type of vegetation throughout the North River Watershed has been significantly altered. Over 18% of the land cover is open; defined as urban, agriculture, rangeland, or barren (Fig. I.1) (The Willapa Alliance 1998). Hardwoods dominate an additional 18% of the area, 11% is mostly early seral stage, 33% mid-seral stage, and 19% late-seral stage conifer. It is noteworthy that the North River Watershed has the greatest percentage of late-seral stage vegetation in WRIA 24.

In watershed analysis, peak flows were rated as a "high vulnerability" for salmon throughout the lower North River Watershed. The effects of high flows varied with the type of channel, ranging from removing cover in the lower mainstem and upper mainstem valley, to reducing LWD in the moderate sized channels, and to scour in the smaller, steeper channels (Herger 1997). The low complexity and lack of side channels throughout the North River, the Little North River, and Vesta Creek, results in few places where juvenile coho and steelhead can escape peak flow energy. The low complexity is related to a lack of LWD and entrenched channels (see Floodplain chapter). Because of the high levels of fines in the watershed, turbidity during high flow events could impact salmon (Herger 1997), but their precise level of impact is unknown.

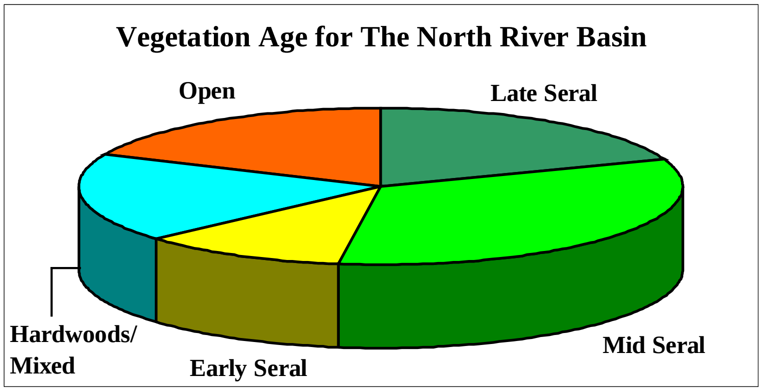
No specific low flow salmon impacts have been noted for this watershed. There are no public water supplies, but there are several private ones in the watershed.

<u>Fall River</u>

High water velocity is a concern for incubating and rearing salmon, and the most likely habitat problems associated with high water velocity are the lack of LWD and pools to slow velocity and provide refuge (Herger 1996). The only rain-on-snow zones are in the headwaters of Boss Creek and the headwaters of the Fall River (Sullivan and Reiter 1996). These areas consist of 80-96% mature conifer and are highly unlikely to contribute to peak flow events. Turbidity during peak flows could be a problem for rearing juveniles and spawning adults.

No specific low flow salmon impacts have been noted for this watershed. There are no public water supplies and three private ones in the watershed (Sullivan and Reiter 1996).

Figure I.1. Vegetation age in the North River Watershed (The Willapa Alliance 1998).



Water Quantity Problems In The Willapa Watershed

The Willapa River has a very wide range of flows due to the geology of the watershed. The river valley consists of shallow alluvial deposits over bedrock. The capacity of the basin for ground water storage is very low (Pickett 1999). Flows can range from 6-10,000 cfs within a year, with the lowest flows typically in August and the highest flows from November through March.

Low flows are a known problem in the upper mainstem Willapa River (legal 13, 8, 36) (Hadley 1994). At the gauge station near Lebam, the annual low flow ranges between 6-12 cfs. The low flow problem occurs in summer and early fall, delaying or even blocking the upstream migration of adult spawning fall chinook. Compounding the problem is a low number of pools for adults to hold until rainfall increases the flows. The delay of adults results in higher harvest, increases disease potential, and potentially reduces reproductive success. The low flows are worsened by water withdrawals and by channel incision. The mainstem in this area is bedrock controlled and dissociated from its floodplain.

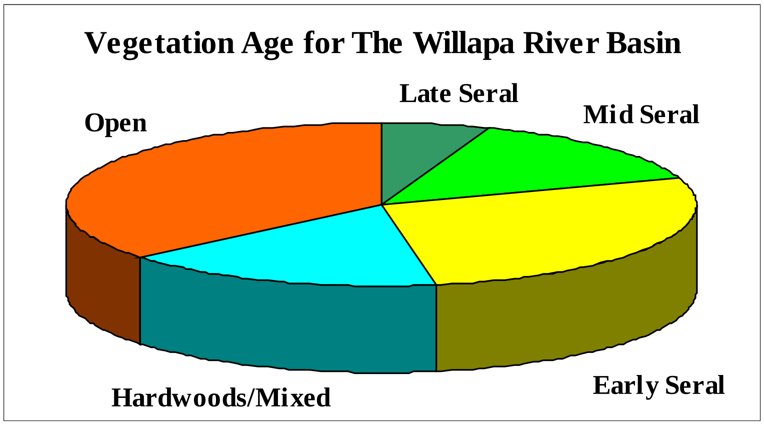
High stream temperature and low dissolved oxygen are also documented problems, which are worsened by the low flows (see Water Quality chapter). These impact juvenile coho and steelhead in addition to returning fall chinook adults. The best summer rearing habitat is located in Stringer Creek, the lower 2.3 miles of Trap Creek, Forks Creek, parts of Ellis Creek, and lower Walker Creek (Hadley 1994). However, many of these same areas are susceptible to winter peak flows which can scour nests and provide poor overwintering conditions. Walker Creek is the exception. It has sufficient LWD and pools to provide both good summer and winter rearing habitat.

Scour due to peak flows was identified as a potential problem in watershed analysis (Sullivan and Carlson 1994). The upper mainstem Willapa, Stringer Creek, Ellis Creek, Trap Creek, and Falls Creek were identified as areas with potential scour problems. Most of these are naturally confined channels, but additional LWD would help slow water velocity and reduce the risk of scour.

In the last 50 years, major storms have altered the Willapa watershed through debris flows from the headwaters (Sullivan and Carlson 1994). These flows deposited large quantities of sediment within stream channels and reduced levels of LWD. Replacing undersized culverts would help reduce the human-caused damage from storm events.

The vegetation type and age has been greatly altered in the Willapa Watershed. This watershed has the greatest percentage of open land in the WRIA (36%) (Fig. I.2). An additional 17% of the area is dominated by hardwoods, 28% is mostly early seral stage, 14% mid-seral stage, and only 6% late-seral stage conifer (The Willapa Alliance 1998).

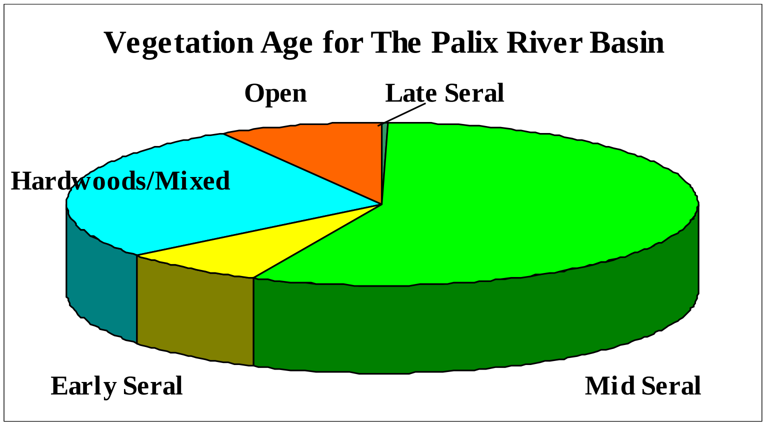
Figure I.2. Vegetation age in the Willapa Watershed (The Willapa Alliance 1998).



Water Quantity Problems In The Palix Watershed

There is no rain-on-snow zone in the Palix Watershed, so peak flows are the result of rainfall. Higher high flows and lower low flows are not believed to be occurring as a result of forest harvests currently, because the majority of the watershed vegetation is over 40 years old (mid seral or older) (Fig. I.3). No specific salmon impacts have been found as a result of current high or low water flows in the watershed. Occasional high water temperatures suggest that monitoring during the summer months should occur to see if low flow conditions are contributing to this problem.

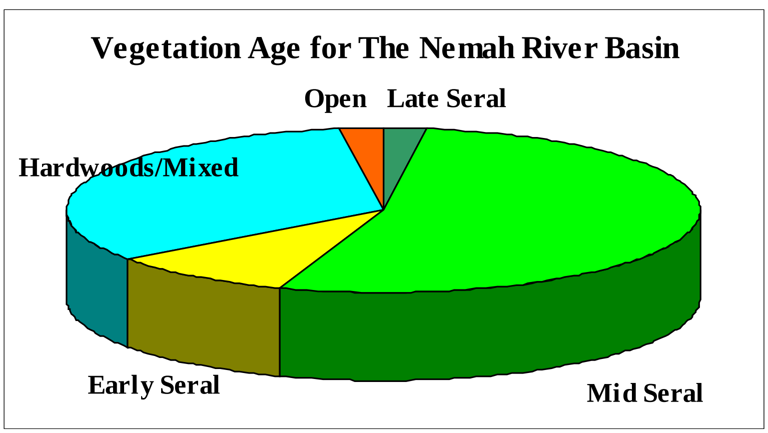
Figure I.3. Vegetation age in the Palix Watershed (The Willapa Alliance 1998).



Water Quantity Problems In The Nemah Watershed

No known low or high flow problems were found for the Nemah Watershed. Summer high water temperatures infrequently exceeded the State standard (see Water Quality chapter). Most of the vegetation within Nemah Watershed is over 40 years old (Fig. I.4) (The Willapa Alliance 1998). However, hardwoods dominate a significant percentage (33%) of the area.

Figure I.4. Vegetation age in the Nemah Watershed (The Willapa Alliance 1998).

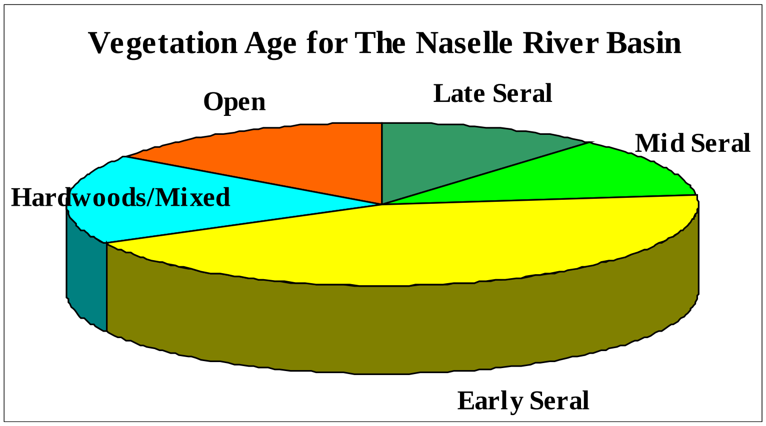


Water Quantity Problems In The Naselle Watershed

The Naselle Watershed had several high temperature exceedances (see Water Quality section), and there is anecdotal information that suggests there are higher high and lower low flows occurring.. Because of the temperature exceedances, future monitoring is needed for temperature, dissolved oxygen and their causes, such as low flows or lack of shade.

There are a low percentage of older conifers throughout the Naselle Watershed. The primary type of land cover is young conifer (early seral), which covers about 44% of the watershed (Fig. I.5) (The Willapa Alliance 1998). Open areas account for 15% and hardwoods dominate 18% of the area. Combined, mid- to late-seral conifers cover only 23% of the watershed.

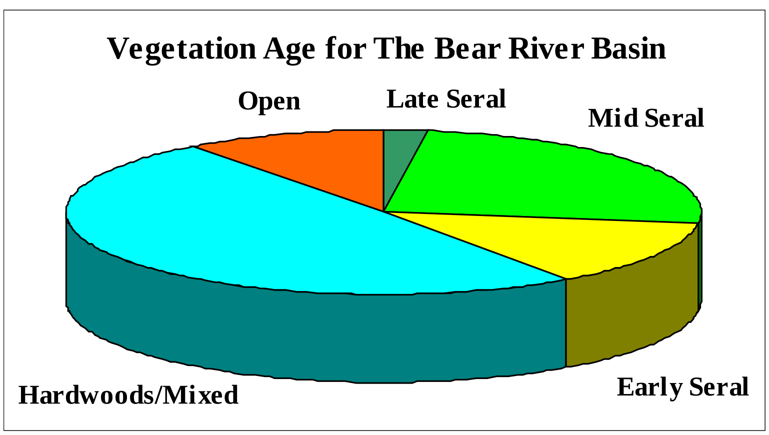
Figure I.5. Vegetation age in the Naselle Watershed (The Willapa Alliance 1998).



Water Quantity Problems In The Bear River

The Bear River Watershed had several high water temperature exceedances (see Water Quality chapter), but no known low flow situations have been noted. Because of the temperature exceedances, future monitoring is needed for temperature, dissolved oxygen and their causes such as low flow or lack of riparian shade. The age and type of vegetation has been greatly altered in the Bear River Watershed. Most of the land cover consists of stands of primarily hardwoods (50%) (Fig. I.6). Only 27% of the basin is dominated by conifers that are older than 40 years (mid- to late seral) (The Willapa Alliance 1998).

Figure I.6. Vegetation age in the Bear River Watershed (The Willapa Alliance 1998).



Data Needs For Water Quantity Issues In WRIA 24

- Conduct studies on the effects of changes in vegetation age and type on in-stream flows and salmon production in WRIA 24.
- Monitor scour and its impact on salmon production in WRIA 24.

J) ESTUARINE CONDITIONS IN WRIA 24

The Willapa Basin estuary consists of about 88,000 acres at mean high tide, with a complete water exchange every 2-3 weeks (The Willapa Alliance 1998). While toxins have not been identified as a problem in the region, *Spartina* invasion is significant. *Spartina* was introduced to Willapa Bay from the East Coast about 100 years ago, and the invasion increased dramatically in the last two decades (DOE 1997). It grows into a "meadow", covering the mudflats. This changes the composition of the mudflat dwellers, displaces native eelgrass, and raises the elevation of the flats.

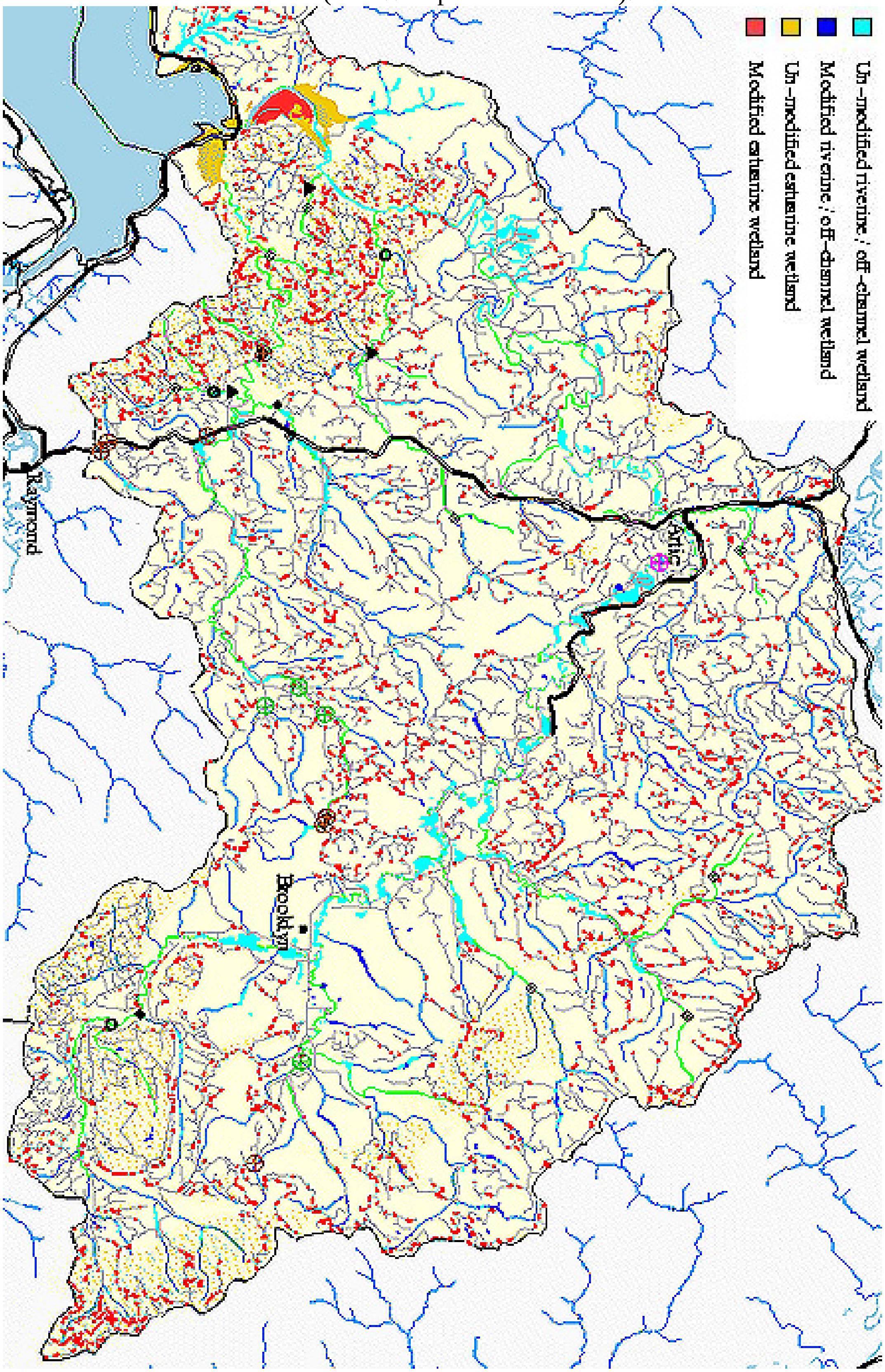
Spartina's impact on juvenile salmon rearing habitat, as well as the ecosystem upon which the young salmon depend is unknown, but the displacement of native eelgrass is a great concern. Eelgrass is important nursery habitat for juvenile salmonids. Juvenile salmon use the eelgrass to hide from predators, as well as feed on copepods that are living on the bacteria from decaying eelgrass (Levings 1985; Webb 1991).

Large woody debris in the estuary was common prior to logging and settlements, but is very low now. Estuarine LWD serves as vital cover for juvenile salmonids (Martin and Dieu 1997). The wood also creates firm substrates in a fine sediment environment, and spruce and cedar grew from nurse logs in the estuary. In estuary type habitat, the presence of LWD is necessary for riparian trees. It is also important substrate for wood dwelling invertebrates, which are an important prey item for juvenile salmonids.

The North River Estuary

Tidal influence in the North River extends to at least RM 7.4 (Phinney and Bucknell 1975), and in this area, about 865 acres of estuarine wetlands have been lost (The Willapa Alliance 1998). This accounts for 31% of the total historical acres of estuary wetlands; a significant loss that is considered a conservative estimate. The lost estuary wetlands, along with existing wetlands are mapped in Figure J.1 (The Willapa Alliance 1998)

Figure J.1. Current (gold) and lost (orange) estuary wetlands in the North River Basin (The Willapa Alliance 1998).

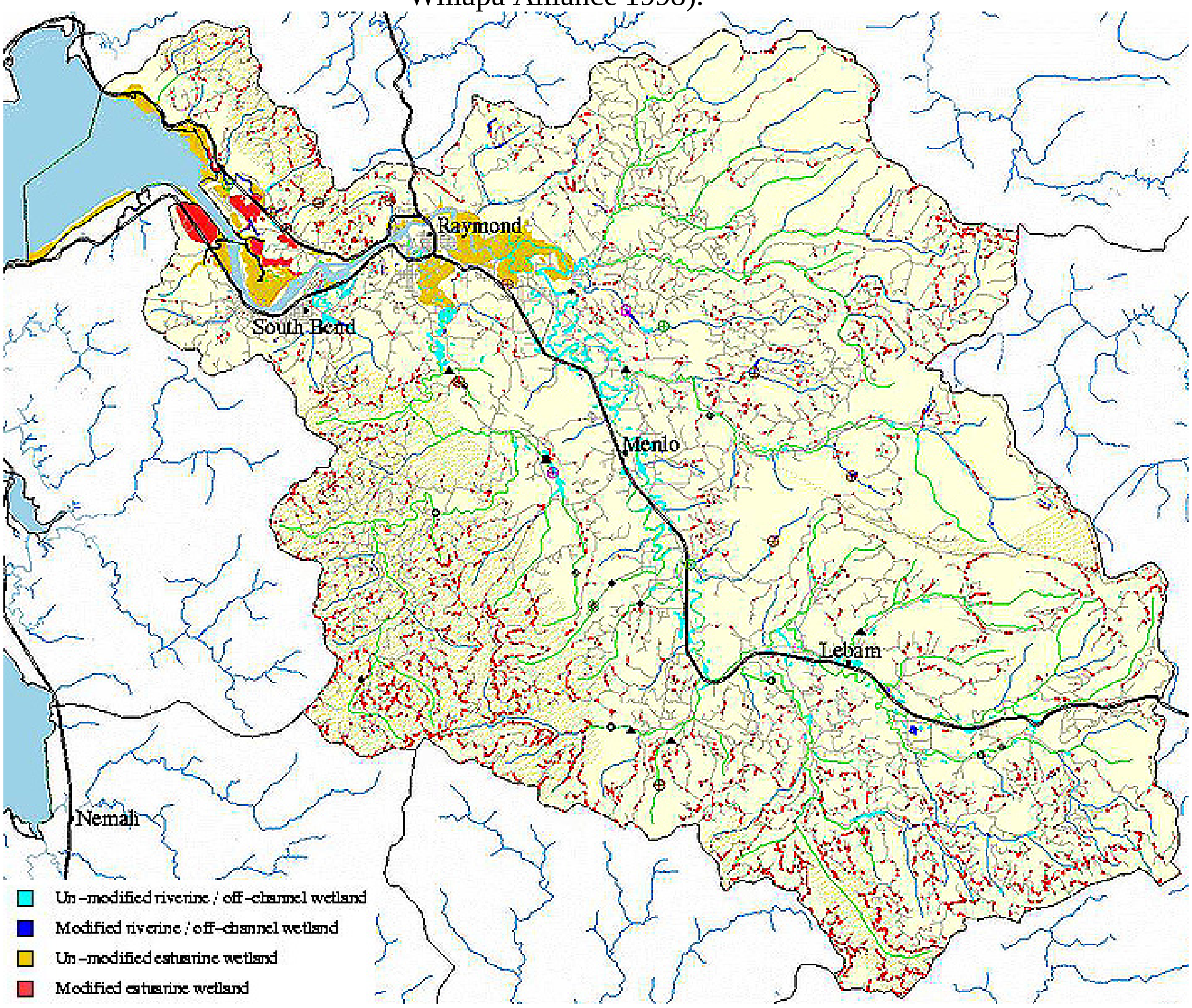


The Willapa River Estuary

In the Willapa River, about 584 acres of estuarine wetlands have been lost, which accounts for 19% of the total historical estuarine wetlands (Fig. J.2) (The Willapa Alliance 1998). Tidal influence extends to around RM 18 in the mainstem Willapa River and to the lower 5 miles of the South Fork Willapa River (Phinney and Bucknell 1975). A bottom of sand, silt, mud and a scattering of gravel characterize these areas. In the lower basin, several sloughs surrounded by marsh grasses serve as important rearing habitat for salmon. Some of these sloughs are Johnson Slough, Fleiss Creek, Electric Light Creek, Pottea Slough, Elk Creek, and Ellis Slough (Phinney and Bucknell 1975).

Maintenance dredging has ceased for the deep-draft channel, but shallow draft project dredging continues, particularly near three small boat basins (USACOE 1998).

Figure J.2. Current (gold) and lost (orange) estuary wetlands in the Willapa River (The Willapa Alliance 1998).



The Palix River Estuary

The Palix WAU hydrologically drains to Willapa Bay (Pentec 1997). The Palix River provides about two thirds of the drainage, while smaller independent streams such as Bruceport, Niawiakum, and Bone Rivers contribute the remaining drainage. Tidal influence extends up through the three major forks of the Palix (North Palix, Middle Palix (Canyon River), and South Palix). The South Fork Palix is extensively under tidal influence. Tidal action in the Niawiakum extends about 3 miles (Phinney and Bucknell 1975).

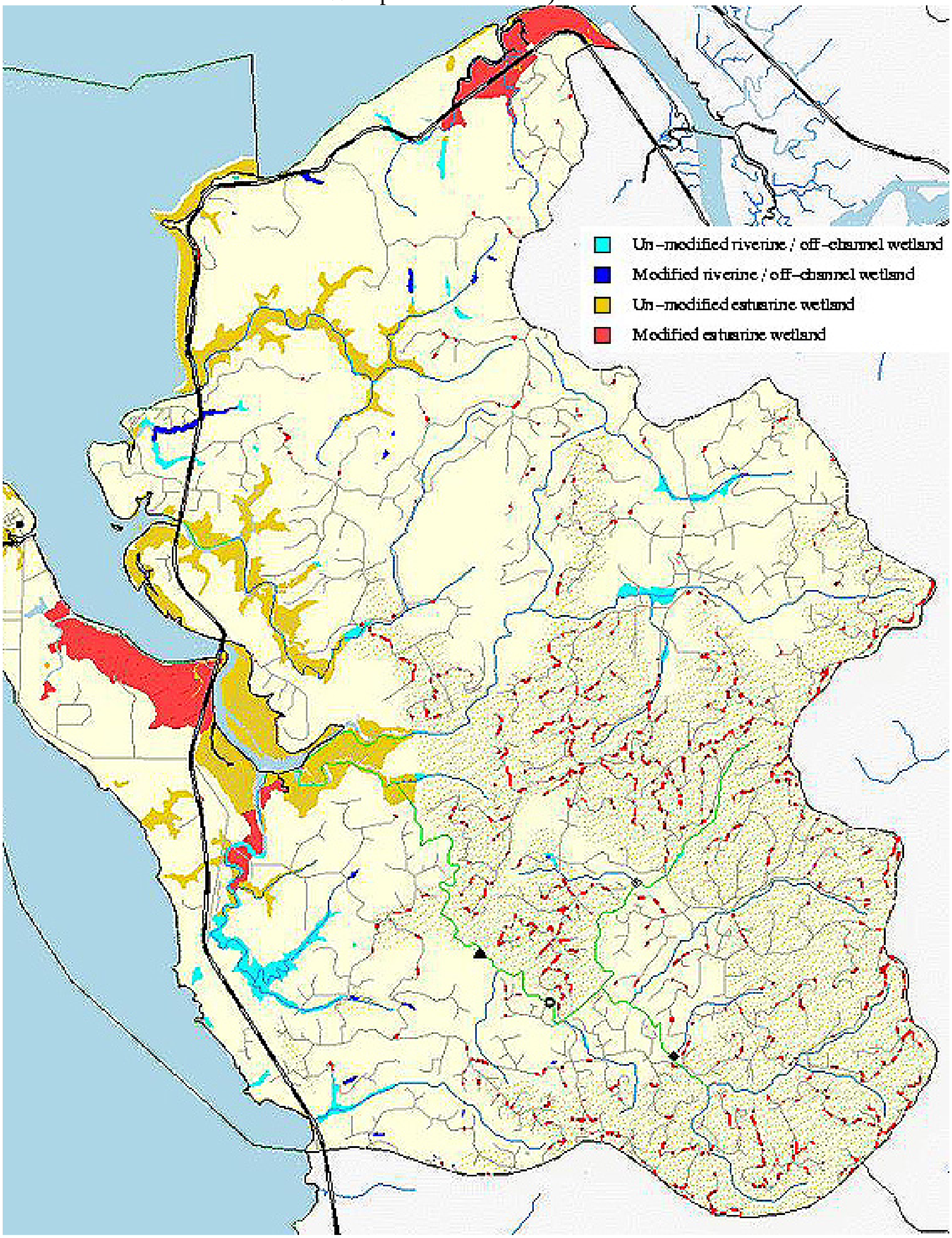
During the late 1800's and early 1900's, settlements were located along the tidelands adjacent to Willapa Bay. Livestock grazing was common and the wetlands were diked and drained to facilitate this land use. The dikes confine the channel, increase scour, reduce alluvial deposition on the flood plain, and reduce complexity. In the early 1900s, the upper intertidal zone of the Bone River were dredged and channelized for steam donkeys. The channels remain straightened today (Pentec 1997). In the Palix Watershed area, about 810 acres of estuarine wetlands have been lost, which accounts for 31% of the total (The Willapa Alliance 1998). This significant loss is mapped in Figure J.3 (The Willapa Alliance 1998).

The Palix River estuary is characterized by tidal channels, mudflats, and saltwater marshes in the intertidal zone, and by gravel deltas, silt-bottomed sloughs and riverine marshes in the backwater zone (where high tide influences). Bank soils are fluvial silt with marsh grasses and shrubs (Pentec 1997). The bottom is sand and silt due to low energy and long distance from coarse sediments. Peak flows and high tides can influence channel morphology.

Estuarine LWD was common prior to logging and settlements, but is very low now Martin and Dieu 1997). It serves as cover for juvenile salmonids, and creates firm substrates (nurse logs) in a fine sediment environment to facilitate the growth of spruce and cedar in the estuary. Near estuarine environments, LWD is necessary for riparian tree growth.

Along the Bruceport, Bone and South Palix estuaries, stream banks are stable and vegetated mostly by marsh grass and shrubs. LWD is nearly absent (Martin and Dieu 1997). The Niawiakum estuarine zone extends about 3.5 miles into the river. The North Palix has a shorter estuarine zone of less than 1 mile long with bedrock outcrops that control the gradient. The Middle Palix has a long estuarine zone that extends about 2 miles. Between RM 2-4.5, the intertidal zone changes to a low gradient flood plain zone. This plain is fairly stable.

Figure J.3. Current (gold) and lost (orange) estuary wetlands in the Palix Watershed (The Willapa Alliance 1998).



The Nemah River Estuary

All three forks in the Nemah system have extensive tidal areas in their lower reaches, and only about 2 acres of estuarine loss has been documented, which accounts for 0.2% of the total (The Willapa Alliance 1998). Even though this estimate is believed to be conservative, the Nemah River estuary is still relatively intact and healthy. The estuary wetlands are identified in Figure J.4 (The Willapa Alliance 1998).

The Naselle River Estuary

Tidal influence extends from the Naselle River mouth to Dell Creek (about RM 10.5), and the width of the lower Naselle River fluctuates greatly with the tide (Phinney and Bucknell 1975). The estuary wetlands associated with the Naselle Watershed are mostly unmodified with only 9 acres lost, accounting for about 0.6% of the total (The Willapa Alliance 1998). Even though the estimate of lost estuary wetlands is believed to be conservative, the Naselle River estuary is in a healthy condition (Fig. J.5).

Figure J.4. Current (gold) and lost (orange) estuary wetlands in the Nemah Watershed (The Willapa Alliance 1998).

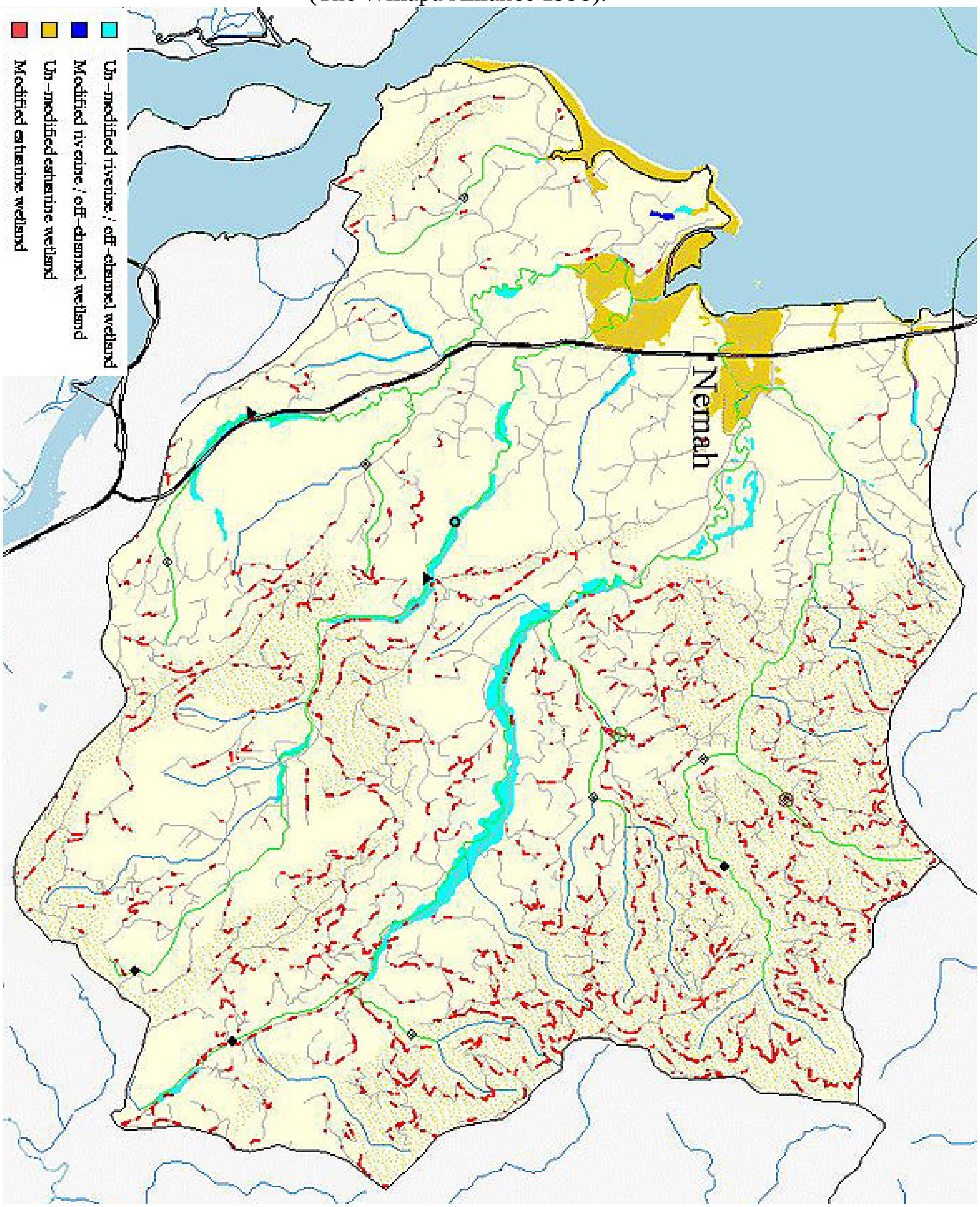
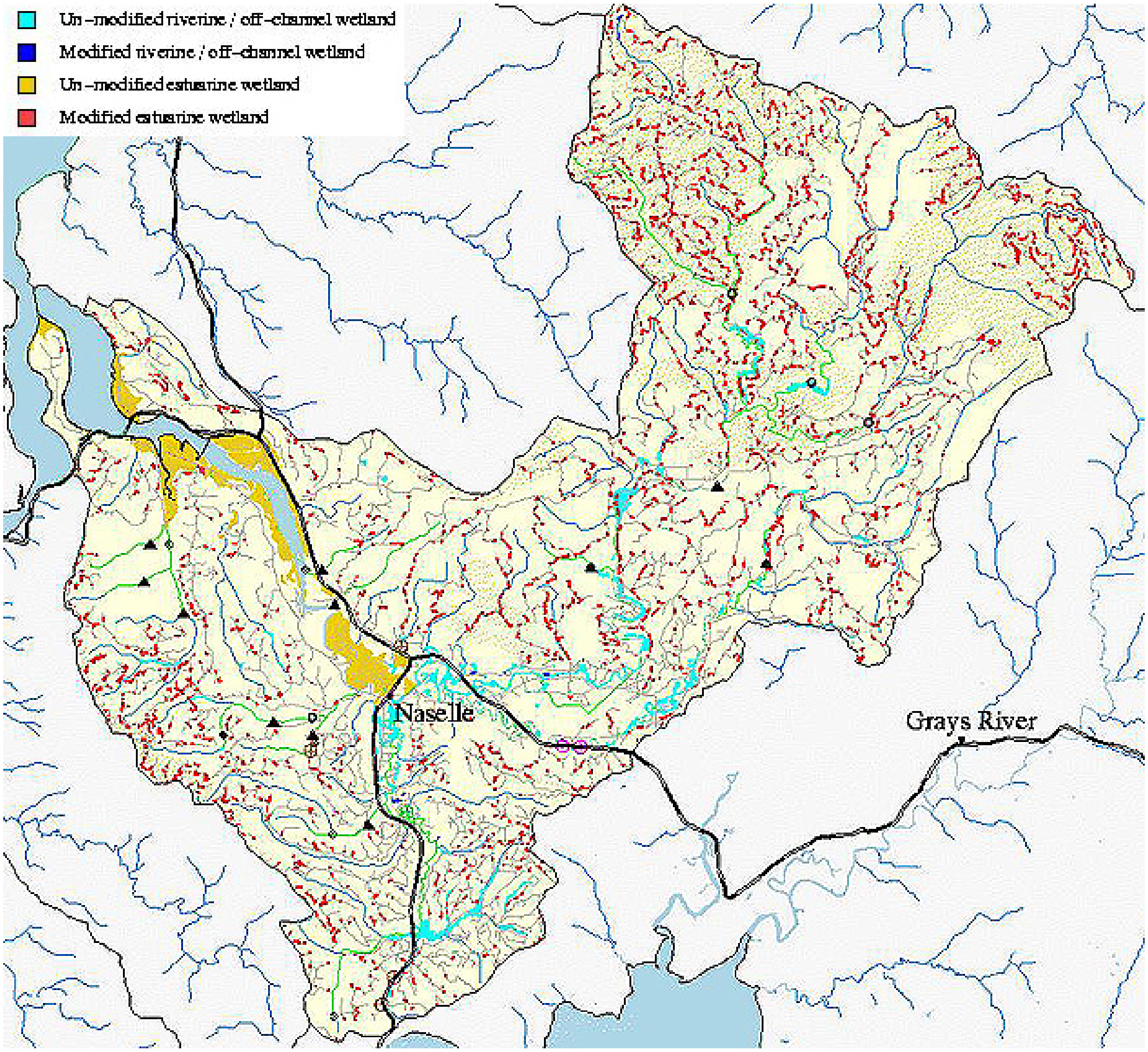


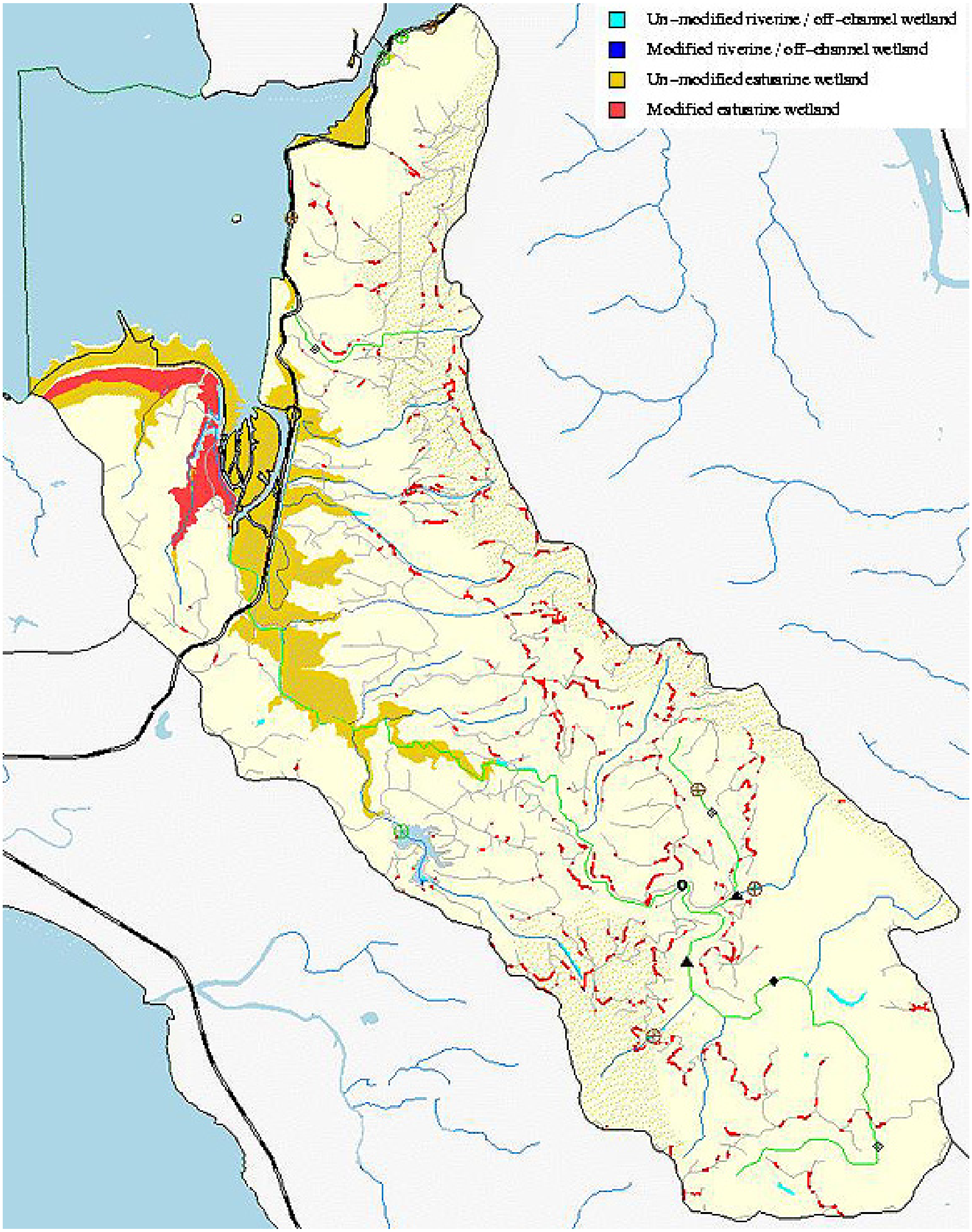
Figure J.5. Current (gold) and lost (orange) estuary wetlands in the Naselle Watershed (The Willapa Alliance 1998).



The Bear River Estuary

The lower 3.5 miles of the Bear River is under tidal influence, and a significant amount (30%) of estuarine wetlands have been lost by diking and draining (Lebovitz 1998). This loss is estimated at over 500 acres and is important for salmon juvenile rearing (Fig. J.6). In the Bear River Conservation and Restoration Plan (Lebovitz 1998), this was rated as the third most important habitat factor limiting salmon production in the watershed. The land lost includes land on both the upstream and downstream sides of Highway 101 near the mouth of Bear River (Lebovitz 1998).

Figure J.6. Current (gold) and lost (orange) estuary wetlands in the Bear River Watershed (The Willapa Alliance 1998).



Data Needs For WRIA 24 Estuarine Habitat

- More accurately identify estuary wetlands and maintain an up-to-date GIS layer to monitor changes.
- Study the effects of *Spartina* invasion on salmon production.

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